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JOURNAL OF PALEONTOLOGY

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EDITORS

A. Scott Warthin, for The Paleontological Society.

J. Marvin Weller, for The Society of Economic Paleontologists and Mineralogists.

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VOLUME 21 | SEPTEMBER, 1947 | NUMBER 5

ORDOVICIAN CEPHALOPODS FROM THE WEST-CENTRAL SHORE OF HUDSON BAY

A. K. MILLER AND WALTER YOUNGQUIST
State University of Iowa, Iowa City, Iowa

ABSTRACT—Two collections of nautilcids from northern Manitoba are illustrated and described. One of these came from dolomite boulders near Churchill, and it contains representatives of the following genera: *Endoceras*, *Floweroceras* n. gen., *Manitoboceras* n. gen., *Gorbyoceras*, *Dowlingoceras?*, *Winnipegoceras*, *Oxygonioceras?*, and *Armenoceras*. The other collection is from dolomite outcrops along the North Knife River, some 25 miles west of Churchill, and it consists of representatives of *Endoceras*, *Lambeoceras*, and *Kochoceras*. The conclusion is reached that both of these faunas are of approximately the same age as the Red River formation of southern Manitoba and the Bighorn formation of the Northern Rockies.

DURING the summer field season of 1946, we collected a variety of nautiloid cephalopods, and a few other fossils, from dolomite boulders in the immediate vicinity of Churchill, northern Manitoba, on the west-central shore of Hudson Bay. Churchill is located on gray pre-Cambrian quartzite, which contains a few isolated rounded cobbles and numerous quartz veins and which is indeed well exposed as it is very resistant to erosion. However, as was long ago noted by Bell (1880, p. 22C) along the shore there, particularly at Battery Point (Cape Merry), boulders of cream-colored dolomite are so abundant that the formation which yielded them almost certainly occurs *in situ* "at no great distance." Much of the dolomite is very fossiliferous, and it contains numerous corals (particularly *Favosites*, *Calapoecia*, and *Streptelasma*) and a variety of brachiopods, gastropods (including *Hormotoma* and *Maclurina*—Pl. 53, figs. 2, 3), and cephalopods. Altogether, we collected the following nautiloids at this locality:

Endoceras spp.
Floweroceras boreale, n. sp.
Manitoboceras hudsonense, n. sp.
Gorbyoceras cf. *G. geronticum* (Foerste and Savage)
Dowlingoceras? sp.
Winnipegoceras laticurvatum (Whiteaves)
Oxygonioceras? sp.
Armenoceras spp.

Furthermore, Mr. Ed Kronlund of Churchill told us that some 25 miles west of Churchill, the same abundantly fossiliferous dolomite outcrops for a distance of about three or four miles along the North Knife and the South Knife rivers, some 35 miles above their common mouth. He added that along the North Knife the valley walls are steep and the exposures excellent, but that along the South Knife the walls are relatively low. Mr. Kronlund kindly presented us with some of the fossils he had collected

along the North Knife, and we are illustrating them under the following names:

Calapoecia canadensis Billings
Maclurina cf. *M. manitobensis* (Whiteaves)
Endoceras spp.
Lambeoceras kronlundi, n. sp.
Lambeoceras cf. *L. lambii* (Whiteaves)
Kochoceras spp.

Almost certainly this assemblage is part of the same fauna that occurs in the dolomite boulders at Churchill, and it is closely related to the faunas of the Shamattawa limestone of the area southwest of Hudson Bay and the Red River formation of southern Manitoba.

In 1927 Foerste and Savage published a detailed report on all of the Ordovician and Silurian cephalopods known at that time from the Hudson Bay area. They had no material from the west-central shore of the Bay, which yielded the specimens we are studying, but they had rather extensive collections from the area south of there, that is, from southwest of Hudson Bay, where Savage and Van Tuyl had shown that there are two Ordovician formations, the Nelson and Shamattawa limestones. Only four species of cephalopods are definitely known to occur in the older of these two formations, the Nelson limestone, but a fifth was found in the drift along the Nelson River and is "presumably from the Nelson limestone." However, the Shamattawa limestone has yielded a great variety of cephalopods consisting of 23 species representing 21 genera, and the general aspect of its fauna is much like that of the collections under consideration, though it is not possible to point out striking similarities.

The faunas of both the Nelson and the Shamattawa are related to those which occur in the well known Red River formation of southern Manitoba. That formation consists of three members, the Dog Head, the Cat Head, and the Selkirk limestones. In 1929 Foerste published a detailed study of the cephalopods of the Red River, of which there were 46 known species. "Of these, 30 occur in the Dog Head limestone, 4 in the Cat Head limestone, and 22 in the Selkirk limestone," several of the species being represented in more than one member. Although the cephalopod fauna of the Dog Head appears to be distinguishable from that of the Selkirk, Foerste recognized that

> when it is attempted to correlate the extensions of the Red River formation in areas remote from southern Manitoba with the members as established in the typical Red River area, difficulties arise. For instance, in the area southwest of Hudson Bay the Nelson limestone may correspond to the Dog Head member of the Red River formation, and the Shamattawa limestone may correspond to the Selkirk member, or may be even of somewhat later age than the Selkirk. . . . At present too little is known of the vertical distribution of fossils from this Red River formation in any area outside of southern Manitoba. This gives special importance to the southern Manitoba area, since it promises to serve as a key in the solution of uncertainties in stratigraphy presented by those areas in which the opportunities for determining the stratigraphic sequence of the different faunas are less favorable. At present the best that can be said of the Red River fauna as a whole is that it can be distinguished readily from the overlying Stony Mountain fauna.

An attempt to compare the fossils we are studying with those that occur in the three members of the Red River formation also leads to unsatisfactory results. That is, although there are close counterparts of the majority of our forms in the Red River fauna, taken as a whole, it is not possible to be certain of a more nearly precise correlation. The difficulties are greatly increased by the fact that both of our collections are relatively small, the preservation of the fossils is only fair, and more than one faunal zone may well be represented in each assemblage. We are therefore able to conclude only that we are dealing with a northern ex-

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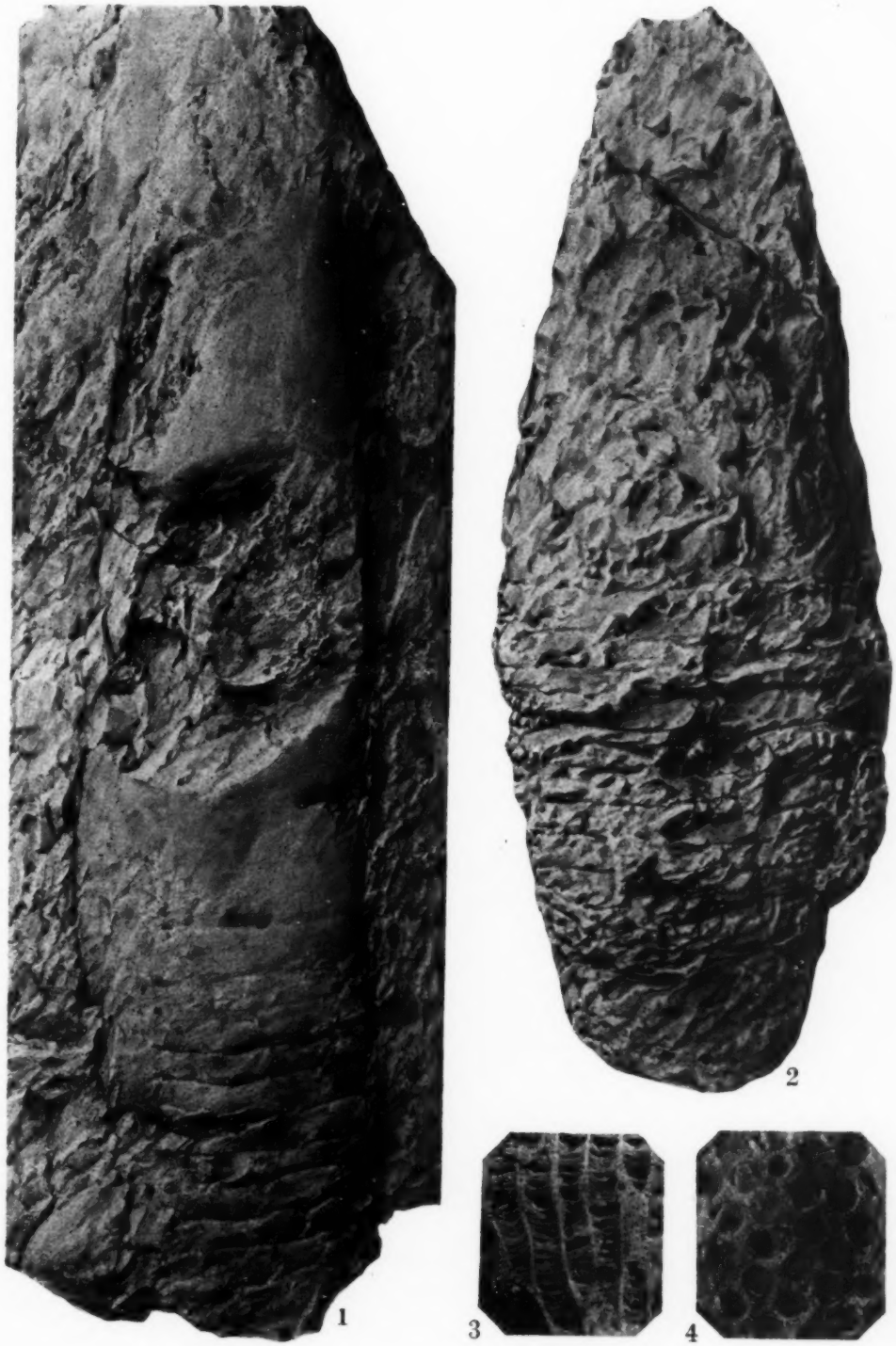
EXPLANATION OF PLATE 52

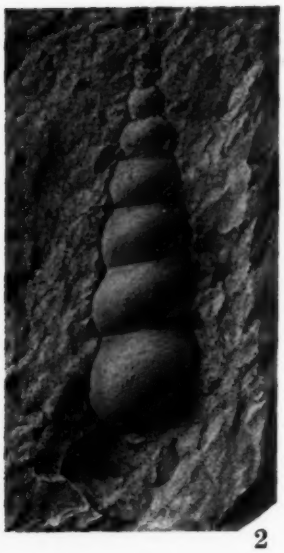
The specimens illustrated on this plate are from boulders of Upper Ordovician dolomite at Battery Point, just northwest of Churchill, Manitoba.

FIG. *1—Endoceras?* sp. A specimen on a dolomite slab, ×1. (p. 412)
2—Dowlingoceras? sp. A fairly complete, but weathered, internal mold, ×1. (p. 415)
3, 4—Calapoecia canadensis Billings. Unretouched photographs of natural longitudinal and transverse sections, ×1½. (p. 411)



Miller and Youngquist, Hudson Bay Ordovician Fossils

1



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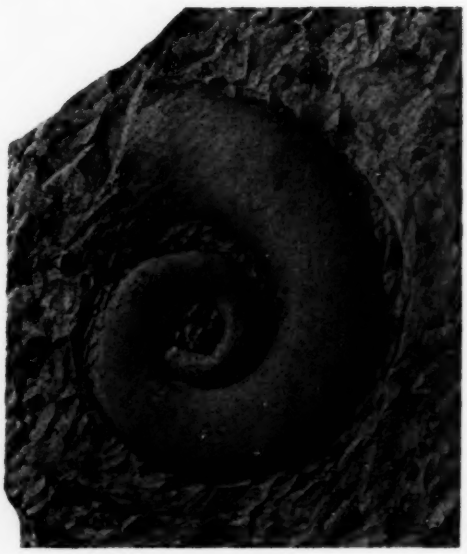

3

4

Miller and Youngquist, Hudson Bay Ordovician Fossils

tension of some portion or portions of the Red River.

Similar northern extensions of this formation are known to occur at various localities in Arctic America, for example, southwestern Victoria and adjacent islands, southern Baffin Island (Foxe Peninsula and Frobisher Bay), and northwestern Greenland (Cape Calhoun beds). Also, the Whitewood, Bighorn, and Fremont formations of western United States contain the same general faunal assemblage, and it can be traced southward into northern Mexico (western Sonora—see Schuchert, 1935, p. 135). However, we still are uncertain in regard to the relationship of this fauna to those of the Stewartville and Maquoketa formations of the Upper Mississippi Valley; the Whitehead formation of Gaspé Peninsula; the English Head, Vauréal, and Ellis Bay formations of Anticosti Island; the Drummuck group of southern Scotland; and the Lyckholm beds of Estonia. Recently Flower has published a large volume on the Ordovician cephalopods of the Cincinnati region, and he (1946, p. 125) has shown that the Arctic cephalopod fauna under consideration seems to have made its appearance there in the Waynesville formation of the Richmond group but reached "its maximum development in the Whitewater and Saluda" formations of the same group. It should perhaps be stated that for some years there has been a difference of opinion as to whether the "Bighorn-Red River" fauna is Mohawkian or Richmondian in age, and therefore Flower's study is far more than ordinarily significant.

We wish to acknowledge our indebtedness to the Graduate College of The State University of Iowa for making the preparation of this report financially possible. The accompanying photographs were retouched by Mr. Howard Webster of Iowa City.

SYSTEMATIC PALEONTOLOGY

CALAPOECIA CANADENSIS Billings

Plate 52, figures 3, 4

The well known compound coral, *Calapoecia*, is present in both of the collections we are studying. It was shown by Cox in 1936 that all of the described representatives of that genus are conspecific and should be referred to *C. canadensis* Billings, which he discussed in detail and synonymized.

Occurrence.—Cox determined (p. 36) that this form appears in the Black River group but is "highly characteristic of post-Trenton and Richmond strata, where it undergoes variation and is widespread," being known "from Alaska eastward to Siberia (excluding the British Isles) and from Kentucky northward to Washington land in Northwest Greenland." It has been reported from numerous Arctic localities, where it seems to be characteristic of the Upper Ordovician. Some of the specimens in the collections under consideration came from cream-colored dolomite boulders near Churchill, Manitoba; the one illustrated (Pl. 52, figs. 3, 4) is from Upper Ordovician dolomite along the North Knife River, some 35 miles above its mouth, northern Manitoba.

Repository.—State University of Iowa, 6947 (Pl. 52, figs. 3, 4), 6948 (unfigured specimens from near Churchill).

HORMOTOMA cf. H. SALTERI Ulrich

Plate 53, figure 2

A high-spired gastropod with rounded whorls was found in northern Manitoba by Mr. E. H. Flewwelling of Halifax, Nova Scotia, who kindly presented it to The State University of Iowa. This specimen consists of seven rounded volutions on which no trace of growth lines or a selenizone is discernible. It is partially imbedded in dolomite matrix, but the exposed portion has an

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EXPLANATION OF PLATE 53

The specimens illustrated on this plate are from boulders of Upper Ordovician dolomite at and near Churchill, Manitoba.

FIG. *1*—*Endoceras* sp. A rather well preserved internal mold of part of a phragmacone, ×1. (p. 412)
2—*Hormotoma* cf. *H. salteri* Ulrich. A specimen in a dolomite slab, ×2. (p. 411)
3—*Maclurina* cf. *M. manitobensis* (Whiteaves). A small specimen imbedded in a dolomite matrix, × 1. (p. 412)
4—*Armenoceras* sp. A siphuncle to which portions of the septa adhere, ×1. (p. 418)

overall length of about 25 mm. Insofar as size and general physiognomy are concerned, it resembles rather closely the type specimens of *H. salteri* Ulrich, but because of its lack of surface ornamentation we are uncertain in regard to its affinities with that species.

Occurrence.—In a cream-colored dolomite boulder at Battery Point, just northwest of Churchill, Manitoba. *H. salteri* (and varieties) are known to occur in the Middle Ordovician of Kentucky, Tennessee, New Jersey, and near the Ontario-Quebec border; and probably in the Upper Ordovician (Cape Calhoun beds) of northwestern Greenland.

Repository.—State University of Iowa, 6949.

MACLURINA cf. M. MANITOBENSIS (Whiteaves)

Plate 53, figure 3; Plate 54, figures 3, 4

Both of the localities on the west-central shore of Hudson Bay from which we have Upper Ordovician nautiloids, have yielded gastropods that are probably referable to *M. manitobensis* (Whiteaves). However, none of the specimens obtained is very complete or retains the surface markings of the test, and therefore the specific affinities are uncertain. Nevertheless, we feel that this form is so characteristic of the Arctic Upper Ordovician molluscan fauna, that its occurrence at these two localities should be recorded and a specimen from each locality should be illustrated so that our identification can be readily verified.

Occurrence.—In cream-colored dolomite boulders at Battery Point, just northwest of Churchill, Manitoba (Pl. 53, fig. 3); and Upper Ordovician dolomite along the North Knife River, some 35 miles above its mouth, northern Manitoba (Pl. 54, figs. 3, 4).

Repository.—State University of Iowa, 6950 (Pl. 53, fig. 3), 6951 (Pl. 54, figs. 3, 4).

ENDOCERAS spp.

Plate 52, figure 1; Plate 53, figure 1; Plate 54, figures 5, 6; Plate 57, figure 4

This ubiquitous genus is well represented in both of the available collections. Our best specimen is illustrated by figure 1 on plate 53. It is an internal mold which is some 115 mm. long and 80 mm. wide, and which represents fourteen camerae of a phragmacone. The sutures of this individual are distinctly oblique to the long axis of the conch, possibly in part at least due to distortion during preservation. The siphuncle is not preserved.

The generic affinities of the specimen illustrated by figure 1 on plate 52 are uncertain. It represents the living chamber and the adjacent portion of the phragmacone. The most distinctive characteristic of this individual seems to be a constriction of the adoral part of the living chamber. The camerae are short and the sutures are essentially straight and directly transverse. Unfortunately, the conch has been flattened and distorted during fossilization, and no trace of the siphuncle is discernible.

The specimen illustrated by figures 5 and 6 on plate 54 represents part of five camerae of a phragmacone. Its conch is depressed dorsoventrally and is broadly elliptical in cross section. The sutures appear to form broad rounded dorsal and ventral lobes and corresponding lateral saddles. The siphuncle is ventral but not marginal in position. The height and width of the siphuncle are some two-fifths the corresponding dimensions of the conch. The siphuncular segments are concave exteriorly.

Figure 4 on plate 57 illustrates a subcylindrical portion of a large siphuncle. It is about 33 mm. in diameter and has an overall length of about 70 mm. In the adoral end of this specimen there is a large subconical spiculum. The generic affinities of this siphuncle are of course very uncertain.

Remarks.—None of these specimens that we are illustrating, nor the congeneric forms in our collections, are particularly significant, for their specific affinities can not be determined. That is, the genus *Endoceras* is world-wide in its distribution, and it is known to range throughout the Ordovician and well up into the Silurian and possibly into the Devonian.

Occurrence.—Boulders of Upper Ordovician dolomite at Battery Point, just northwest of Churchill, Manitoba (Pl. 52, fig. 1; Pl. 53, fig. 1; and several unfigured specimens); and Upper Ordovician dolomite along the North Knife River, some 35 miles above its mouth, northern Manitoba (Pl. 54,

figs. 5, 6; Pl. 57, fig. 4). Most of our specimens from Battery Point were found in boulders of cream-colored dolomite, but the one illustrated on plate 53 is in brownish-gray dolomite which contains small crystals of quartz and cupriferous pyrite.

Repository.—State University of Iowa, 6952 (Pl. 52, fig. 1), 6953 (Pl. 53, fig. 1), 6954 (Pl. 54, figs. 5, 6), 6955 (Pl. 57, fig. 4), 6956 (unfigured specimens).

Genus FLOWEROCERAS Miller and Youngquist, n. gen.
Genotype: *Floweroceras boreale* Miller and Youngquist, n. sp.

Conch straight, moderately expanded orad, depressed dorsoventrally, flattened ventrally, and subelliptical in cross section. Surface markings unknown. Septa occur in pairs. The adoral septum of each pair is strongly curved apicad. The marginal portions of the adapical septum of a pair curve orad from the sutures. The suture formed by the adapical septum of a pair is straight and almost directly transverse, whereas that of the adoral septum of a pair forms a broad rounded ventral lobe. Siphuncle large, and ventral but not marginal in position and apparently cyrtochoanitic in structure, with septal necks at least partially adnate to the septa.

No forms are known to us that are at all closely similar to this one. Presumably, therefore, it should be regarded as representing a distinct family, the Floweroceratidae. Its most diagnostic characteristic is its sutures. The genus is so far known only from Upper Ordovician dolomite boulders of northern Manitoba.

The generic name is given in honor of Dr. Rousseau H. Flower of the New York State Museum, who has added greatly to our knowledge of Paleozoic cephalopods.

FLOWEROCERAS BOREALE Miller and Youngquist, n. sp.
Plate 55, figures 1–5

This species is based on two internal molds, both of which represent parts of phragmacones. The better (Pl. 55, figs. 1–3) is being chosen as the holotype. It is about 60 mm. long, and near its mid-length its maximum height and width measure about 22 mm. and 29 mm., respectively. As shown by the accompanying illustrations, the conch is moderately expanded orad. In cross section it is subelliptical as it is depressed dorsoventrally and is flattened ventrally. No trace of the surface marking is discernible on either of the type specimens.

The septa are aberrant. They can be said to occur in pairs, and at least the adoral one of each pair is strongly curved apicad. The marginal portions of the adapical septum of each pair are curved orad from the test—that is, from the suture—but the rest of the septum is curved apicad. On the internal mold, the adapical septum of a pair forms a suture that is essentially straight but slopes slightly apicad toward the dorsum. However, the adoral septum of each pair forms a suture that is straight and directly transverse on only the dorsal zones of the internal mold inasmuch as on the lateral and ventral zones the adoral suture of a pair curves apicad to form a broad rounded ventral lobe—although the two sutures converge ventrally, they do not quite come in contact with each other even along the venter.

The siphuncle is large and is ventral but not marginal in position. Its structure is not fully elucidated by either of the type specimens. However, on the extreme adapical portion of each specimen, there is a suggestion that the connecting rings were adnate to the adjacent septa for a width of about 1 mm., which indicates that the siphuncular segments are greatly expanded within the camerae and that the siphuncle was therefore cyrtochoanitic in structure.

Remarks.—The paratype is slightly larger than the holotype and presumably it represents a more adoral portion of the phragmacone. Aside from size, the two specimens do not appear to differ materially. As this form is the only known representative of the new genus, *Floweroceras*, specific comparisons are superfluous.

Occurrence.—In a boulder of light-brown dolomite at Battery Point, just northwest of Churchill, Manitoba.

Types.—State University of Iowa, 6957 (holotype), 6958 (paratype).

Genus MANITOBOCERAS Miller and Youngquist, n. gen.
Genotype: *Manitoboceras hudsonense* Miller and Youngquist, n. sp.

Conch rather small, straight, depressed dorsoventrally, flattened dorsally, narrowly rounded laterally, broadly rounded ventrally, subelliptical in cross section, and contracted adorally as well as adapically. Aperture appears to be large and subterminal. At least dorsal portions of sutures straight and directly transverse. Siphuncle small at its passage through the septa and central or nearly so in position.

We are very uncertain in regard to the affinities of this genus. Superficially it resembles certain arthropods and chitons, but we regard it as related to the nautiloids—tentatively we would group it with the Mixochoanities. The only specimens that we are referring to the genus came from a boulder of Upper Ordovician dolomite in northern Manitoba.

MANITOBOCERAS HUDSONENSE Miller and Youngquist, n. sp.
Plate 55, figures 6–10

The holotype of this species (Pl. 55, figs. 7–10) is about 37 mm. long, and it attains a maximum width of about 18½ mm. and a maximum height of some 10 mm. It is essentially straight, though slightly distorted during preservation. Its conch is contracted both orad and apicad, and the holotype is rounded both adorally and adapically—it appears to be bounded adapically by a septum, or an impression of one. The conch is depressed, is flattened dorsally, narrowly rounded laterally, and broadly rounded ventrally. The aperture seems to be large and to be subterminal. In general, the holotype has more or less the shape of a moccasin upside down.

On the dorsal side of the holotype there are four straight directly transverse grooves that appear to represent sutures. However, they can be traced only part way across the lateral zones, and the ventral side of the specimen is poorly preserved. At the extreme adapical end of the holotype there is a structure, somewhat less than 1 mm. in diameter, that may represent the siphuncle.

In addition to the holotype, we found a specimen (Pl. 55, fig. 6) that we are referring with question to this species. It is about 41 mm. long and 25 mm. wide, and in cross section it seems to resemble the holotype. It is rather narrowly rounded adapically and is broadly rounded adorally. As in the holotype, the dorsal side of this individual is crossed by four transverse grooves. However, the conch of this specimen is considerably wider than that of the holotype, and the two may not be conspecific.

Remarks.—No forms are known to us that are sufficiently close to this one to justify detailed comparisons.

Occurrence.—Boulder of light-brown dolomite at Battery Point, just northwest of Churchill, Manitoba.

Repository.—State University of Iowa, 6959 (holotype), 6960 (specimen referred with question to this species).

GORBYOCERAS cf. G. GERONTICUM (Foerste and Savage)
Plate 56, figure 1

(?) *Spyroceras geronticum* FOERSTE and SAVAGE, 1927, Denison Univ. Bull., Jour. Sci. Labs., vol. 22, pp. 38–39, pl. 5, figs. 2, 3; pl. 6, figs. 1A, 1B.
(?) *Metaspyroceras geronticum*, FOERSTE, 1932, Denison Univ. Bull., Jour. Sci. Labs., vol. 27, pp. 111–112.
(?) *Metaspyroceras geronticum*, MILLER and CARRIER, 1942, Jour. Paleontology, vol. 16, p. 537.
(?) *Gorbyoceras geronticum*, FLOWER, 1946, Bull. Am. Paleontology, vol. 29, no. 116, p. 148.
(?) *Gorbyoceras* cf. *G. geronticum*, MILLER and YOUNGQUIST, 1947, Jour. Paleontology, vol. 21, pp. 14–15, pl. 8, figs. 1–3.

EXPLANATION OF PLATE 54

The specimens illustrated on this plate are from Upper Ordovician dolomite along the North Knife River, some 35 miles above its mouth, northern Manitoba.

FIGS. *1, 2*—*Lambeoceras kronlundi* Miller and Youngquist, n. sp. Lateral and dorsal views of the holotype, ×1. (p. 416)
3, 4—*Maclurina* cf. *M. manitobensis* (Whiteaves). Two views of an incomplete whorl, ×1. (p. 412)
5, 6—*Endoceras* sp. Dorsal and lateral views of part of a phragmacone, ×1. (p. 412)

Miller and Youngquist, Hudson Bay Ordovician Fossils

Miller and Youngquist, Hudson Bay Ordovician Cephalopods

The only representative of the Spyroceratidae that we found is an impression of part of a conch that is considerably curved longitudinally. Although the preserved portion of this specimen is only some 40 mm. long, it bears seven transverse annulations. The test is also marked by fine longitudinal raised lines, which are rather prominent and on the average are some 2 mm. apart but are somewhat irregular in their spacing.

Remarks.—In all available particulars, this specimen seems to resemble rather closely one of the paratypes of "*Spyroceras*" *geronticum* Foerste and Savage (1927, pp. 38–39, pl. 5, figs. 2, 3). However, inasmuch as it is very incomplete and does not retain the internal structures of the conch, even its generic affinities are uncertain. It should perhaps be mentioned that although typical members of the Spyroceratidae have straight conchs, one of the three type specimens of *G. geronticum* is distinctly curved and so are a good many other similar forms (Miller and Carrier, 1942, p. 537).

Occurrence.—Boulder of brownish-gray dolomite (containing a 3-inch cobble of gray quartzite, presumably Churchill quartzite) at Battery Point, just northwest of Churchill Manitoba. The type specimens of *G. geronticum* came from the Shamattawa limestone along the Shamattawa River, southwest of Hudson Bay, and specimens that may be conspecific are known from the Upper Ordovician of Sutton Island in the southwestern part of the Canadian Arctic Archipelago.

Repository.—State University of Iowa, 6961.

DOWLINGOCERAS? sp.
Plate 52, figure 2

A straight brevicone was found near Churchill that at least superficially resembles *Dowlingoceras? piersalense* Teichert of the Lyckholm beds of Estonia. This specimen is an internal mold of a living chamber and much of the phragmacone. It is considerably weathered but in cross section is elliptical, and its shorter diameter appears to be only about half its longer diameter. The maximum dimensions of the conch are attained somewhat apicad of the adoral end of the phragmacone, and the living chamber is contracted adorally throughout its entire length.

The camerae are moderate in length, and the septa are not very strongly curved. The sutures are almost straight but form shallow rounded lobes on wider sides of conch A break along a septum in the adoral third of the phragmacone reveals a structure that may represent the siphuncle. It is some 3 mm. in diameter and is located some 10 mm. from one of the narrower sides of the conch.

Remarks.—The preservation of this specimen leaves much to be desired, and because of the uncertainty in regard to its siphuncle, we are not able to assign it definitely to a genus. However, in general physiognomy it appears to resemble representatives of *Dowlingoceras* more closely than those of any other genus known to us.

Occurrence.—In a cream-colored dolomite boulder at Battery Point, just northwest of Churchill, Manitoba.

Repository.—State University of Iowa, 6962.

WINNIPEGOCERAS LATICURVATUM
(Whiteaves)
Plate 56, figure 2

Cyrtoceras laticurvatum WHITEAVES, 1895, Canadian Rec. Sci., vol. 6, pp. 395–396.
Cyrtoceras laticurvatum WHITEAVES, 1897, Canada Geol. Surv., Palaeozoic fossils, vol. 3, pt. 3, pp. 224–225, text fig. 14.
Winnipegoceras laticurvatum, FOERSTE, 1928, Michigan Univ., Mus. Paleontology, Contr. vol. 3, pp. 56–58, pl. 9, figs. 1, 2.
Winnipegoceras laticurvatum, FOERSTE, 1935, Denison Univ. Bull., Jour. Sci. Labs., vol. 30, pp. 38–39, pl. 4, fig. 2.
Winnipegoceras laticurvatum, ROY, 1941, Field

EXPLANATION OF PLATE 55

The specimens illustrated on this plate are from boulders of Upper Ordovician dolomite at Battery Point, just northwest of Churchill, Manitoba.

FIGS. *1–5*—*Floweroceras boreale* Miller and Youngquist, n. sp. Three views of the holotype (figs. *1–3*) and two of the paratype (figs. *4*, *5*), ×1. (p. 413)
6–10—*Manitoboceras hudsonense* Miller and Youngquist, n. sp. Dorsal view of a specimen referred with question to this species (fig. *6*), ×1; and four views of the holotype (figs. *7–10*) ×2. (p. 414)

Mus. Nat. Hist., Geol., Mem., vol. 2, pp. 143–144, text fig. 105.

Winnipegoceras laticurvatum, MILLER and CARRIER, 1942, Jour. Paleontology, vol. 16, pp. 540–541, pl. 78, fig. 6.

We found a single representative of this species on the west-central shore of Hudson Bay. It is an internal mold of a living chamber and the adoral four camerae of the phragmacone. Its maximum length measures about 113 mm., of which some 20 mm. represents phragmacone.

The dorsal side of this specimen is slightly concave and the ventral side is convex. The cross section is broadly elliptical, but the individual we are studying has been slightly crushed and distorted. At the junction of the phragmacone and the living chamber, the conch is about 49 mm. high, and its corresponding width is estimated to be some 30 mm. As shown by the accompanying illustration, throughout the length of the living chamber the conch decreases in size adorally.

The camerae are moderately short, and the adoral one is particularly so, indicating that we are dealing with a fully mature individual. Along the lateral zones of the conch, the length of the adoral camera measures about 3 mm., and those of the preceding camerae measure some 5 mm., 6 mm., and 6 mm., respectively. The sutures form broad rather shallow rounded lateral lobes and corresponding dorsal and ventral saddles. The siphuncle is not visible.

Remarks.—Although our specimen is not very complete and is somewhat distorted, it appears to resemble rather closely the corresponding portions of the holotype of this species. It is not very close to the other named representatives of this genus, *W. dowlingi* Foerste of the Dog Head member of the Red River formation of southern Manitoba and *W. fragmentarium* Strand of the Gastropod limestone near Oslo, Norway. Also, it appears to be quite distinct from the unnamed congeneric specimen that Miller and Furnish (1937, p. 550, pl. 69, fig. 2) illustrated and described from the Whitewood formation of the Black Hills, South Dakota.

Occurrence.—In a cream-colored dolomite boulder at Battery Point, just northwest of Churchill, Manitoba. Conspecific specimens are known from the Dog Head member of the Red River formation of southern Manitoba, the Bighorn formation of the Wind River (Lander sandstone member) and Bighorn mountains of Wyoming, and the Upper Ordovician limestone that constitutes Silliman's Fossil Mount near the head of Frobisher Bay, Baffin Island. A closely related form has been described from the Matapedia beds of southeastern Quebec (Miller and Furnish, 1937, pp. 550–551, pl. 69, fig. 1).

Repository.—State University of Iowa, 6963.

LAMBEOCERAS KRONLUNDI Miller and Youngquist, n. sp.
Plate 54, figures 1, 2

The specimen on which this species is based is an internal mold of a living chamber which is essentially complete adorally and which is bounded adapically by an impression of part of the adoral septum of the phragmacone. Its maximum length measures about 78 mm., and near its adoral end it is about 24 mm. high and 46 mm. wide. As shown by the accompanying illustrations, the conch is expanded orad rather gradually and is distinctly flared near the apertural margins. In cross section it is sublenticular as it is subangular laterally and is broadly rounded both dorsally and ventrally but is more strongly convex dorsally.

EXPLANATION OF PLATE 56

The specimens illustrated on this plate are from boulders of Upper Ordovician dolomite at and near Churchill, Manitoba.

FIG. *1*—*Gorbyoceras* cf. *G. geronticum* (Foerste and Savage). An external mold of part of a conch, ×1. (p. 414)

2—*Winnipegoceras laticurvatum* (Whiteaves). Lateral view of the living chamber and the adjacent portion of the phragmacone, ×1. (p. 415)

3, 4—*Armenoceras* spp. Internal molds of two siphuncles, ×1. (p. 418)

5—*Oxygonioceras?* sp. A specimen on a slab of dolomite, ×1. (p. 418)

1

2

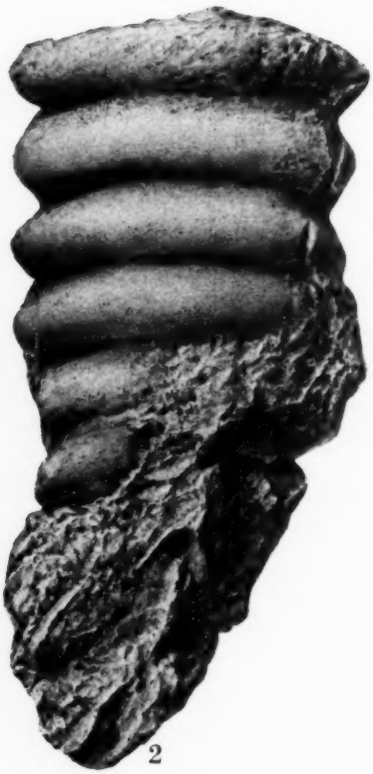
3

4

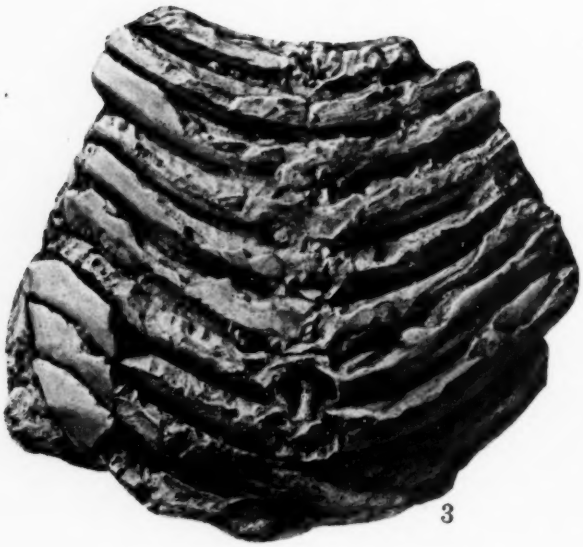
5

Miller and Youngquist, Hudson Bay Ordovician Cephalopods

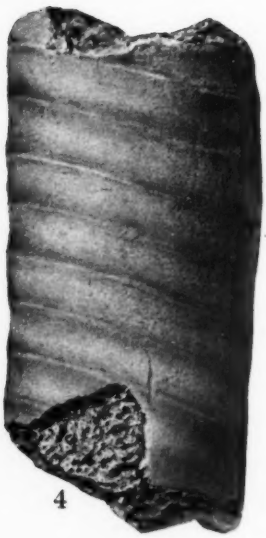
1



2



3



4

Miller and Youngquist, Hudson Bay Ordovician Cephalopods

The dorsal portions of the apertural margins are essentially straight and directly transverse to the long axis of the conch. The ventral portions of these margins are unfortunately not preserved, and no trace of the growth lines is discernible on the holotype.

The single septum that is represented is rather strongly curved laterally but only slightly curved dorsoventrally. Each suture forms broad rounded dorsal and ventral lobes and subangular lateral saddles. No trace of the siphuncle is retained on the holotype.

Remarks.—This specimen is strikingly similar to the holotype of *Lambeoceras peculiare* Miller, which came from the Lander sandstone member of the Bighorn formation of Wyoming. Both have relatively large living chambers and similar cross sections, but the conch of the Wyoming species is somewhat more rapidly expanded orad. The specific name is given in honor of Mr. Ed Kronlund of Churchill, Manitoba, who found the specimen on which the species is based and presented it to The State University of Iowa.

Occurrence.—Upper Ordovician dolomite along the North Knife River, some 35 miles above its mouth, northern Manitoba.

Holotype.—State University of Iowa, 6964.

LAMBEOCERAS cf. L. LAMBII (Whiteaves)
Plate 57, figure 3

(?) *Gonioceras Lambii* WHITEAVES, 1892 [1891], Roy. Soc. Canada Trans., vol. 9, sec. 4, pp. 86–87, pl. 11, figs. 1–1b.

(?) *Triptoceras lambi*, [part] CLARKE, 1897, Minnesota Geol. and Nat. Hist. Surv., vol. 3, pt. 2, pp. 793–794 [not pl. 56, figs. 1, 2].

(?) *Tripteroceras Lambii* WHITEAVES, 1897, Canada Geol. Surv., Palaeozoic fossils, vol. 3, pt. 3, pp. 213–214.

(?) *Lambeoceras lambii*, FOERSTE, 1929, Denison Univ. Bull., Jour. Sci. Labs., vol. 24, pp. 213–215, pl. 34, fig. 1.

(?) *Lambeoceras lambei*, LEITH, 1942, Jour. Paleontology, vol. 16, pp. 130–132, pl. 22, figs. 1–7.

The collections under consideration contain a specimen that resembles rather closely the genoholotype of *Lambeoceras*. It is an internal mold representing much of ten camerae of a phragmacone. The overall length of this specimen measures about 70 mm., and its maximum width (in its present incomplete state) is about 75 mm. The conch is lenticular in cross section and near the adapical end of our specimen the maximum height of conch is estimated to have been some 25 mm.

The septa are rather strongly curved laterally, but their dorsoventral curvature is only moderate. The siphuncle is ventral but not marginal in position. At the adoral end of the holotype it is broadly elliptical in cross section at its passage through a septum, being about 5 mm. wide and 4 mm. high, and it is located at least 5 mm. from the ventral wall of the conch. However, the siphuncular segments are greatly expanded within the camerae, and in the adapical third of our specimen they attain a maximum width of at least 11 mm.

Remarks.—This specimen is incomplete, and its rate of adoral expansion is indicated by only a small portion of one lateral margin (see lower left-hand part of figure 3 on plate 57). Nevertheless, all of its characteristics that can be determined seem to coincide well with those of the genoholotype, *L. lambii* (Whiteaves) of the Selkirk member of the Red River formation of southern Manitoba. Congeneric forms are now known to be widespread in the Upper Ordovician of North America, including the Canadian Arctic Archipelago and Greenland. They have been recorded from Northwestern Greenland, Baffin and Iglulik islands, southern Manitoba, Wyoming, South Dakota?, Minnesota, Illinois, Indiana, and Ohio. The

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EXPLANATION OF PLATE 57

The specimens illustrated on this plate are from Upper Ordovician dolomite along the North Knife River, some 35 miles above its mouth, northern Manitoba.

FIGS. *1, 2*—*Kochoceras* spp. Ventral view of an internal mold of a phragmacone (fig. *1*) and dorsal view of a siphuncle (fig. *2*), ×1. (p. 418)

3—*Lambeoceras* cf. *L. lambii* (Whiteaves). Ventral view of an incomplete phragmacone, ×1. (p. 417)

4—*Endoceras?* sp. Part of a large siphuncle, ×1. (p. 412)

genus appears to be an excellent guide to the Upper Ordovician.

Occurrence.—Upper Ordovician dolomite along the North Knife River, some 35 miles above its mouth, northern Manitoba. Similar specimens, which may be conspecific, are known from the Selkirk member of the Red River formation of southern Manitoba and the Upper Ordovician of Cockburn Land, Baffin Island.

Repository.—State University of Iowa, 6965.

OXYGONIOCERAS? sp.
Plate 56, figure 5

On a slab of dolomite we found a specimen that represents part of a conch that appears to be concave dorsally and to be lenticular in cross section. Its general physiognomy suggests that it is breviconic. Near the mid-length of this specimen there is a structure, some 10 mm. from the dorsum, that may represent the siphuncle. If so, the siphuncular segments are rather small and are not greatly expanded within the camerae.

Remarks.—Superficially this specimen resembles *Oxygonioceras? latum* Foerste of the Dog Head member of the Red River formation of southern Manitoba, but in that species the siphuncle is located fairly close to the venter. Neither of these forms is very closely similar to the genotype of *Oxygonioceras*, *Trochoceras oxynotum* Barrande of the Silurian of Bohemia, and they are almost certainly not congeneric with it.

Occurrence.—In a cream-colored dolomite boulder at Battery Point, just northwest of Churchill, Manitoba.

Repository.—State University of Iowa, 6966.

ARMENOCERAS spp.
Plate 53, figure 4; Plate 56, figures 3, 4

Actinoceratoid siphuncles that are circular or nearly so in cross section are not rare in the Upper Ordovician dolomite of northern Manitoba. It is now recognized that the genus *Armenoceras* differs from *Actinoceras* chiefly in the shape of the siphuncular segments. That is, in *Armenoceras* the septal necks are very short and are so rapidly expanded within the camerae that much of the brim is in contact or nearly so with the adjacent septa, and the adapical portions of the connecting rings are also adnate to the septa. These criteria lead us to refer to *Armenoceras* the specimens illustrated by figure 4 on plate 53 and figures 3 and 4 on plate 56.

Remarks.—It should probably be pointed out that the specimens we are studying represent only the siphuncle, to which in the case of the individual illustrated by figure 4 on plate 53 portions of the septa adhere. Accordingly, their affinities are none too definite.

Occurrence.—Upper Ordovician dolomite boulders at and near Churchill, Manitoba. The specimen represented by figure 4 on plate 53 was found by Mr. Jack Bird of Brandon, Manitoba, who kindly loaned it to us for study.

Repositories.—Private collection of Jack Bird of Brandon, Manitoba (Pl. 53, fig. 4); and State University of Iowa, 6967 (Pl. 56, fig. 3), 6968 (Pl. 56, fig. 4), 6969 (unfigured specimens).

KOCHOCERAS spp.
Plate 57, figures 1, 2

Two of the nautiloid cephalopods known from the Upper Ordovician dolomite along the North Knife River of northern Manitoba are actinoceratoids in which the siphuncle is large, is not circular in cross section, and appears to have been in flattened contact with the ventral wall of the conch. The septal necks are short, but they are longer than those of typical *Armenoceras* and are not in contact with the adjacent septa. The conch of the specimen illustrated by figure 1 on plate 57 is moderately expanded orad, and the sutures of this individual form broad rounded ventral lobes. The camerae of both our specimens are of about average length for the genus.

Remarks.—Inasmuch as the specimen illustrated by figure 2 on plate 57 represents only the siphuncle, we are somewhat uncertain in regard to its generic affinities. However, in all available details it seems not to differ materially from typical representatives of *Kochoceras*. The other specimen we are studying (Pl. 57, fig. 1) is more nearly complete and its relationships are therefore easier to ascertain.

Occurrence.—Upper Ordovician dolomite along the North Knife River, about 35

miles above its mouth, northern Manitoba.

Repository.—State University of Iowa, 6970 (Pl. 57, fig. 1), 6971 (Pl. 57, fig. 2).

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EARLY ORDOVICIAN CEPHALOPODS FROM ADAMSFIELD, TASMANIA

CURT TEICHERT
Mines Department, Melbourne

ABSTRACT—A small fauna of endoceroids from limestones near Adamsfield, in southwestern Tasmania, consists of the following species: *Piloceras tasmaniense*, n. sp., *Manchuroceras steanei*, n. sp., *Manchuroceras excavatum*, n. sp., *Utoceras ?* sp., *Suecoceras robustum*, n. sp., and *Endoceras* sp. This fauna includes the first piloceroids ever found in the Australasian region. It indicates the occurrence in Tasmania of beds of the age of the Beekmantown (=Skiddavian of Britain and Wolungian of Manchuria). The paper includes a discussion of some aspects of the major classification of the Endoceroidea and a description of some structural features of the siphuncle of *Manchuroceras*.

OCCURRENCE

THE CEPHALOPODS described in the present paper were obtained on Adams Creek, about one mile west of Adamsfield, in southwestern Tasmania, during the sluicing of osmiridium-bearing alluvial deposits, when the fossils were apparently washed out of the weathered top part of the underlying limestones.

The general geology of the Adamsfield district has been described by P. B. Nye in 1929 and was later investigated by D. E. Thomas (typewritten report, Mines Department, Tasmania) who pointed out that the sequence here consisted of conglomerates at the base, followed by sandstones which in turn were overlain by a thin veneer of limestones. It is from this layer that the fossils were obtained.

On lithological grounds Nye proposed a correlation of these rocks with the Silurian Gordon River limestones, but from general field evidence Lewis suggested that the Adamsfield limestone is more probably a continuation of the Junee limestones of early Ordovician age (Lewis, 1940). From Junee Kobayashi described (1940) a small *Asaphopsis-Tasmanaspis-Lecanospira* fauna of early Ordovician age and Thomas (1945, p. 23) reported the presence of Junee species in the sandstones overlying the conglomerates in the Adamsfield district, thus corroborating Lewis' field correlations. The study of the cephalopods from the slightly higher limestone serves to substantiate both Lewis' and Thomas' correlation and Kobayashi's determination of the age of the Junee limestone.

Most of the specimens described below were obtained during 1945 and 1946 by Mr. David Steane and sent to Professor S. W. Carey, then Government Geologist of Tasmania, who in turn forwarded them to me for identification. However, the occurrence of cephalopods in these beds had first been noticed by Dr. D. E. Thomas in 1944 who obtained specimens of *Endoceras s.l.* from the same locality. I am greatly indebted to Dr. Thomas, and especially to Dr. Carey, for having given me the opportunity of studying this interesting material.

AGE OF ASSEMBLAGE

The fauna comprises four new species of piloceroids, here described as *Piloceras tasmaniense*, *Manchuroceras steanei*, *Manchuroceras excavatum*, and *Utoceras?* sp., in addition to two endoceroids one of which cannot at present be distinguished generically from described species of *Suecoceras* and is here called *Suecoceras robustum*, whereas the other is an indeterminate species of *Endoceras*.

Piloceroids are widely distributed in northeastern Asia and in north America and they occur more rarely in Scotland. Their age is invariably Beekmantown ("Upper Canadian") and its equivalents—Skiddavian in Great Britain, Wolungian in Manchuria and north China. The latter Kobayashi has called the "age of Piloceroids."

The occurrence of *Suecoceras* in the same beds with piloceroids is somewhat puzzling. True *Suecoceras* is at present only known from Sweden where Holm described a number of species from his "*Lituites* limestone" which corresponds to the upper part of the "*Orthoceras* limestone" in the more generally accepted classification. The "*Orthoceras* limestone" is generally regarded as an equivalent of the Llanvirn and Llandeilo of Britain and of the Chazy of North America, but if Ulrich (1929, p. 88) is correct in correlating it with the Buffalo River series, the time interval between the occurrence of the piloceroids and that of *Suecoceras* in Europe would be greatly reduced. Even so, *Suecoceras* is decidedly, if slightly, younger than the "age of piloceroids."

For the present it may be considered that the piloceroids carry more weight in correlation. They are a well defined group with a short time range, whereas the group of endoceroids to which *Suecoceras* belongs are generally poorly known and their taxonomic relationships imperfectly understood.

It is, therefore, suggested that the Adamsfield limestone is of lower Ordovician age (Beekmantown = Skiddavian = Wolungian) and is thus approximately contemporaneous with the limestones of the Junee River from which Kobayashi (1940) described *Lecanospira*, *Asaphopsis*, and *Tasmanaspis*, as well as other forms. The fact that this Junee fauna seems to be present in layers immediately below the limestones at Adamsfield suggests possibilities for a more detailed zoning of these early Ordovician deposits in Tasmania.

MAJOR CLASSIFICATION OF ENDOCEROIDEA

Most genera of this group are longiconic forms, but there is a significant assemblage of brevicones which among themselves exhibit a considerable degree of variation and should, therefore, be distinguished as a group of higher than family rank. These are the piloceroids and I, therefore, agree with the fundamental division of the Endoceroidea into Endoceracea and Piloceracea as proposed by Kobayashi in 1936. The family grouping given by that same author in 1935 (p. 750) is probably also essentially correct.

The Endoceracea include the Endoceratidae, Proterocameroceratidae (see below), Wolungoceratidae, Baltoceratidae, and Troedssonellidae; the Bathmoceratidae may belong here and the Cyclendoceratidae of Shimizu and Obata (1936) may constitute a valid family to which belong *Cyclendoceras*, *Kotoceras*, and *Catoraphiceras*, but not *Protocycloceras* which is orthochoanitic.

Whether or not the Piloceracea should be further subdivided into Piloceratidae, Manchuroceratidae, and Chihlioceratidae as was advocated by Kobayashi and others, is at present difficult to decide, because the state of our knowledge concerning the various genera is rather unequal and the structure of some, *e.g.*, *Chihlioceras*, should be reinvestigated. For the present I would be satisfied to follow Ulrich, Foerste, and Miller (1943) and leave all the genera concerned in one family, at the same time definitely recognizing the superfamily rank of the whole group.

Further discussions of some of the taxonomic aspects concerned as well as morphological descriptions of some internal structures of Piloceracea will be found in the descriptive part of the paper below.

TAXONOMY OF ENDOCERACEA

In 1936, Shimizu and Obata established the family Suecoceratidae which, in the revised definition given by Ulrich, Foerste, Miller, and Unklesbay (1944, p. 127) includes endoceroids in which "the adapical portions of both the conch and the siphuncle are rapidly expanded orad and then slightly curved endogastrically and contracted dorsally, so that they are asymmetrically spear-shaped." Even so it seems that this family does not rest on a very firm foundation in shell morphology, because not all its members are curved endogastrically near the apex (comp. *Penhsioceras* Endo and "*Endoceras*" *belemnitiforme* Holm) and also because the genera differ among themselves in important morphological features.

Taxonomic treatment of this entire group is made very difficult by the fact that so little is known about the apical end of true Endoceratidae. Such forms as *Endoceras* and *Cameroceras* belong to the earliest recognized types of nautiloids, but the apical

ends of their typical species are unknown.[1]

The apical end of some endoceroids was studied many years ago by Holm and by Clarke, and later by Ruedemann. Their studies are now classical. *Nanno* Clarke is certainly a very striking and distinct type, but as pointed out by Foerste (1932, p. 70) it is hardly possible to compare it with *Endoceras*, because the apical part of the siphuncle of the latter is so incompletely known.

For a discussion of the various genera concerned the reader may safely turn to recent papers by Kobayashi (1937) and by Ulrich, Foerste, Miller, and Unklesbay (1944). Looking at the various types with known apical ends it seems to me that they fall into two very distinct groups:

(1) conchs in which the apical part for a length equalling the height of several of the later camerae is entirely occupied by the siphuncle;

(2) conchs in which the first air chamber was built adjacent to the initial part of the siphuncle.

In group (1) the nepionic shell was a small cone which later formed the apical portion of the siphuncle. At some stage of growth, when the cone was 2 or 3 cm. long or even longer, its lumen became constricted, and then only did the construction of the septate portion of the phragmocone begin. To this group belong *Nanno* and *Proterocameroceras*, possibly *Foerstella* Kobayashi; and possibly also *Penhsioceras* and *Subpenhsioceras* (if the latter is indeed a valid genus).

In group (2) septation of the conch began in the nepionic stage and the siphuncle was distinct from the chambered portion of the phragmocone at a much earlier stage. Here belong *Suecoceras*, *Mysticoceras* and probably numerous other endoceroids whose siphuncles are known to taper gradually towards the apex.

Kobayashi's division of the Endoceratidae into Endoceratinae and Proterocameroceratinae seems to have little basis in reality, being based entirely on the shape of the apical portion of the conch without regard to its internal structure. I agree however with Kobayashi in placing *Suecoceras* with the Endoceratidae, if this name may be applied to the second group of genera mentioned above.

The difference in structure between *Suecoceras* and *Nanno* is of more than generic rank. It may therefore be suggested to raise Kobayashi's Proterocameroceratinae to full family rank and redefine the family Proterocameroceratidae in such a way as to include endoceroids which built an aseptate conical shell in the nepionic stage.

[1] Kobayashi (1937, p. 11) was wrong in believing that the holotype of *Cameroceras trentonense* Hall has a siphuncle with preserved apical end. As is clear from the description by Foerste (1924) the endocone only is preserved.

DESCRIPTIVE PART

Family ENDOCERATIDAE
Genus ENDOCERAS Hall
ENDOCERAS sp.

This genus is represented by two fragments of siphuncles. The larger one of these is an internal mould which is 35 mm. long. Its dorso-ventral diameter increases gradually from 3.6 mm. to 7.0 mm., its lateral diameter from 3.7 mm. to 8.1 mm. The lateral and dorsal surfaces are crossed by slightly oblique annulations (indicating the site of the septal necks) which slope adapically from the ventral towards the dorsal side. They are discontinuous across the ventral side where the presence of a gradually widened smooth area indicates close contact of the siphuncle with the wall of the conch.

The interior of the siphuncle is entirely filled with crystalline calcitic matter, undoubtedly the result of recrystallization of the endosiphosheaths.

Specimens 48817 and 48818, Mines Department of Victoria, Melbourne.

Genus SUECOCERAS Holm
SUECOCERAS ROBUSTUM Teichert, n. sp.
Plate 58, figures 4–5

This species is based on a single specimen which is an internal mould of part of a siphuncle. It is 55 mm. long and on the whole slightly curved, with its ventral side somewhat concave, its dorsal side slightly convex. More accurately the outline of the ventral side is described as slightly sinuous, because of the somewhat inflated apical portion of the siphuncle.

From the acute apex the siphuncle increases rapidly in diameter, mainly through

swelling along the dorsal side. It reaches its greatest diameter of 11.2 mm. (measured dorso-ventrally) at a place about 19 mm. from the apex. The lateral diameter is here 11.5 mm., so that the cross-section is very nearly circular. From this place the siphuncle tapers gradually to a dorso-ventral diameter of 10.0 mm. and a lateral diameter of about 7.0 mm. The cross-section of the siphuncle thus becomes considerably compressed adorally.

The surface of the siphuncle is rather prominently annulated, the annulations representing the lines along which the septa were bent into the septal necks. The annulations are absent from a narrow zone along the ventral side of the siphuncle, where apparently it was in contact with the wall of the conch. They slope adapically from the ventral side at an angle of about 30°. The number of annulations in a length equal to the dorso-ventral diameter of the siphuncle varies between 5 in the bulbous part and 4 in the compressed adoral part of the siphuncle. The width of the area along which the siphuncle was in contact with the ventral wall of the conch is about 3.5 mm. Near the adoral end of the specimen a fragment of the wall of the conch adheres to the ventral side of the siphuncle.

The cross-section at the adoral end of the siphuncle shows the presence of a more or less centrally situated endocone, almost circular in cross-section, with a diameter of about 3.5 mm. It tapers rapidly and continues into an endosiphotube. The rest of the specimen consists of crystalline calcitic substance in which no trace of the original endosiphosheaths can be detected.

Holotype.—73×15, Geological Survey, Mines Department, Hobart, Tasmania.

Remarks.—True *Suecoceras* has heretofore been known only from Sweden where Holm (1896) described five species from the upper "*Orthoceras* limestone." A sixth, unnamed, species is known from boulders in the Pleistocene drift of northern Germany. From all of these the Tasmanian species is distinguished by its greater size. The siphuncle of the largest species of the genus, *S. barrandei*, figured by Holm 1896, pl. 3 fig. 8, has a maximum diameter of 6.5 mm. Other specimens of this species as well as other representatives of the genus are smaller. *S. robustum* approaches a number of the smaller species of *Nanno* in size, but the fact that the annulations on the surface of the siphuncle extend right to the apical end clearly indicates its affinities to *Suecoceras*. It also has the characteristic ventral outline of the Swedish species described by Holm.

The specimens from China which Grabau, in 1922, described as *Suecoceras yehliense* and *S. attenuatum* hardly belong to this genus, because they expand gradually from the apex and show no decrease in diameter adorally. Their apical portion definitely does not have the bulbous shape characteristic of *Suecoceras*. It seems that Shimizu and Obata (1935, p. 3) had intended to include these two species in a new genus "*Changkiuoceras*," but since the genotype of this genus, especially designated as such by the authors, is a *nomen nudum*, the name *Changkiuoceras* can have no standing in nomenclature. In view of the very fragmentary state of preservation of the types of Grabau's species it seems inadvisable to assign them to a new genus until the holotypes and if possible topotypes have been studied.

Family PILOCERATIDAE
Genus PILOCERAS Salter
PILOCERAS TASMANIENSE Teichert, n. sp.
Plate 58, figures 9–11

This species is established for a single well-preserved siphuncle which is slightly curved, slowly expanding in diameter, and rather strongly compressed in cross section.

Its length, measured along the convex dorsal side, is about 80 mm. The amount of curvature increases towards the adoral end of the specimen. The apex of the siphuncle is broken off. At the adapical end the dorso-ventral diameter now measures 9 mm., the lateral diameter 6.5 mm. The corresponding figures at the adoral end are 23 mm. and 15.5 mm. The cross section at the adoral end is oval, flattened laterally and with the ventral side much more narrowly rounded than the dorsal side.

The surface of the siphuncle bears rather prominent, broadly rounded annulations. In the apical portion of the specimen these slope dorsad as they cross the lateral sides, but towards the adoral end the obliqueness decreases and they become almost trans-

verse, forming a shallow lateral sinus along the sides of the siphuncle. The annulations are well marked on all sides of the siphuncle, thus indicating that the latter was not in close contact with the ventral wall of the conch.

At the adoral end the specimen is mostly filled with rock matrix, except along the dorsal and ventral sides where layers of calcitic deposit are in evidence. These thin out laterally and are absent from the lateral surfaces of the siphuncle.

Holotype—73×14, Geological Survey, Mines Department, Hobart, Tasmania.

Remarks—The present species differs from other known species of *Piloceras* in its smaller rate of expansion. In this respect it comes closest to *Piloceras hornei* Ulrich, Foerste, and Miller (1943, p. 23), which however is somewhat less strongly curved. The few other species of the genus are all larger, less strongly curved, and more rapidly expanding. This applies also to *Parapiloceras shimizui* Obata from northeastern China which, as already suggested by Ulrich, Foerste, and Miller, is hardly sufficiently different from *Piloceras* to warrant generic distinction.

Genus MANCHUROCERAS Ozaki

The genus *Manchuroceras*, established by K. Ozaki in 1927, did not become well known until 1935 when Kobayashi restudied the genotype and affiliated species. In 1939, Obata described and illustrated a number of additional species. Ulrich, Foerste, and Miller (1943, p. 18) briefly discussed the genus and listed its known representatives.

Kobayashi's emended diagnosis of the genus *Manchuroceras* reads as follows:

> Breviconic orthoceracone, straight or little curved, subcircular to ovate in cross section; siphuncle large, cylindrical, straight or slightly curved, marginal, subcircular or ovate, and dorsoventrally-depressed in cross section; its ventral side frequently flattened; septa holochoanitic; septal suture oblique to the axis of the siphuncle, ascending from dorsum to venter; apical part of the siphuncle conical, sometimes provided with a mammilary scar; endocone off-center, close to the dorsum, its ventral wall mostly concave, forming ventral elevation.

Kobayashi described transverse partitions of the endosiphotube (inadvertently called "endosiphuncle," 1935, p. 739) of *Manchuroceras wolungense*. No further observations can be offered on this point.[2]

Kobayashi described furthermore how the "siphuncular wall" of *Manchuroceras* increases in thickness from the dorsal to the ventral side "and abruptly swells up inward, forming the ventral elevation." In reality, conditions as observed in *Manchuroceras steanei*, to be described below, are a little more complicated: the "siphuncular wall" occupies the space originally taken up by the endosiphosheaths, very

[2] Contrary to Kobayashi's opinion there is no analogy between these "endosiphuncular segments" and supposedly similar structures of the endosiphotube of *Narthecoceras crassisiphonatum* (Whiteaves). As pointed out by me in 1934, p. 40 Whiteaves' figure is somewhat misleading; what appear to be transverse partitions are in reality transverse sections of longitudinal sheaths within the endosiphotube. The longitudinal section of the siphuncle shown by Whiteaves is very slightly oblique to the axis of the endosiphotube.

EXPLANATION OF PLATE 58

All specimens are in the collections of the Mines Department, Hobart, Tasmania. All figures are natural size.

FIGS. *1–3*—*Manchuroceras excavatum* Teichert, n. sp. Dorsal, apical and lateral views of the holotype. (p. 427)

4, 5—*Suecoceras robustum* Teichert, n. sp. Lateral and dorsal views of the holotype. (p. 422)

6–8—*Manchuroceras steanei* Teichert, n. sp. Dorsal, apical and lateral views of the holotype. (p. 426)

9–11—*Piloceras tasmaniense* Teichert, n. sp. Lateral, apical and dorsal views of the holotype. (p. 423)

12—*Manchuroceras steanei* Teichert, n. sp. Apical aspect of paratype, showing silicified endosiphoblades. (p. 426)

13–15—*Utoceras?*, sp. Dorsal, apical and lateral views. (p. 427)

Teichert, Tasmanian Ordovician Cephalopods

often so strongly recrystallized diagenetically that individual sheaths can no longer be distinguished. Thus a "wall" is indeed formed, as described by Kobayashi, which may be either uniform in thickness all around the siphuncle or else increasing or decreasing in thickness, either dorsally, ventrally or laterally. The inner side of the "wall" indicates the position of the latest formed endosiphosheath and inside it is the original endocone. This endocone however, —and this is one of the distinguishing features of *Manchuroceras*—is further constricted by a separate deposit, apparently formed after the completion of the last endosiphosheath. This deposit is wedge-shaped, with a lenticular cross-section, and fills a certain space in the ventral portion of the endocone. It may be known as the *endosiphowedge*. In the holotype of *Manchuroceras steanei* it can be clearly demonstrated that the endosiphowedge is a structure quite distinct from the endosiphosheaths.

Apparently in most Asiatic specimens described by Kobayashi and by Obata recrystallization has obliterated the boundary between these two structures.

Another interesting structure is seen in a paratype of *Manchuroceras steanei* which shows clearly developed, silicified, triradiate endosiphoblades, comparable to those first described in other endoceroids by Holm and by Ruedemann.

Structures which were later called endosiphoblades were probably first described by Dewitz in 1880 and by Dawson, in 1881, in a paper which is not available to me in Australia. They were more carefully studied by Holm in 1885 (pp. 14–16) in specimens of a species then called *Endoceras gladius*, but later transferred to *Nanno belemnitiforme* (Holm 1896). Holm found that in some of his specimens the calcitic substance which results from the recrystallization of the endosiphosheaths was divided by three thin vertical membranes issuing from the endosiphotube. These membranes divided the endosiphuncle into three more or less equal compartments. In 1895 Holm called these membranes endosiphoblades, a name later accepted by Ruedemann (1905), who found identical structures in specimens of *Proterocameroceras brainerdi* and described them in considerable detail. His explanation of them was that the endosiphoblades represented calcified remnants of membranes by means of which the visceral sac was suspended in the siphuncle, prior to the formation of the endosiphosheaths.

Structures resembling Holm's endosiphoblades were observed in *Piloceras* by Foord (1887; see also Bather 1894, p. 433). In the apical portion of *Piloceras* siphuncles Foord noticed a dark membrane, dividing the recrystallized filling of the siphuncle into two somewhat unequal parts. A similar membrane connecting the endosiphotube with the ventral wall of the siphuncle was seen by Kobayashi in *Manchuroceras* and *Coreanoceras* (Kobayashi, 1935, 1936). It seems unlikely that Ruedemann's interpretation of the triradially arranged blades of *Proterocameroceras* as suspensory organs of the visceral sac can hold true in cases where the blades are lateral or ventral in position.

While it is probably true that, as Ulrich, Foerste, and Miller suggest (1943, p. 17), strong internal wrinkling of the endocone may have been mistaken for endosiphoblades, it is equally true that not all endosiphoblades can be explained in this way. On the other hand endosiphoblades may have originated in the first instance from lateral folds of the visceral sac, squeezed out between the growing endosiphosheaths,

Ruedemann described somewhat related structures in *Piloceras* (now *Cassinoceras*) *explanator* as "endosiphofunicles." These are membranous threads or funicles connecting the endosiphotube with the siphuncular wall, thus penetrating the endosiphosheaths. Ruedemann ascribed to the endosiphofunicles of *Cassinoceras* the same function as to the endosiphoblades of *Proterocameroceras*. The discovery of true endosiphoblades in *Manchuroceras* lends support to this view. These structures will be described in more detail below.

In conclusion it may be suggested that the endosiphuncular structures of endoceroids and related eurysiphonate nautiloids are greatly in need of intense studies. Only then will it be possible to reach a better understanding of the biological functions of the siphuncle of such eurysiphonate forms, a subject about which we know little at present.

MANCHUROCERAS STEANEI
Teichert, n. sp.
Plate 58, figures 6–8, 12

The holotype of this species is part of an internal mould of a siphuncle which is 46.4 mm. long. It is entirely straight and its diameter increases rapidly from the apex. At a distance of 11 mm. from the apex the dorso-ventral diameter is 16.0 mm., the lateral diameter 15.8 mm. The corresponding figures at the adoral end of the specimens are 19.0 and 19.8 mm. Thus the cross-section of the siphuncle is almost perfectly circular.

The outside of the specimen seems to be smooth for a distance of at least 15 mm. from the apex. Farther adorally the surface is covered with rather sharp-crested annulations which slope from the ventral side dorsad at an angle of about 30°. There are about seven annulations in a length equalling the diameter of the siphuncle. Across the venter there is a broad zone, at least 9 mm. wide, from which the annulations are absent, indicating a broad and intimate contact between the siphuncle and the ventral wall of the conch. In spite of this the flattening of the ventral side of the siphuncle, though noticeable, is not very strong.

The inner side of the siphuncle is lined with calcitic matter, obviously recrystallized endosiphosheaths. This lining is thinnest on the dorsal side where, at a distance of 36 mm. from the apex, it is 2 mm. thick. It thickens toward the lateral sides to 3.7 mm. and decreases again to 2.0–2.5 mm. along the ventral side. The ventral side of the siphuncle, however, is strengthened by a further deposit of lenticular cross section which forms the endosiphowedge. At the adoral end of the specimen the endosiphowedge is 4 mm. thick so that the total thickness of the "wall" of the siphuncle is here 6 mm. The inner surface of the endosiphowedge bears two parallel faint ridges which run longitudinally slightly off the center of the wedge.

The endocone is long and slowly tapering and reaches to within 15 mm. of the apex of the siphuncle. It continues into an endosiphotube which pierces the apex of the specimen. The cross-section of the endocone is somewhat subtriangular. At a distance of 37 mm. from the apex of the siphuncle its greatest lateral diameter is 13 mm., its dorso-ventral diameter 8 mm. The base of the triangular cross section is formed by the endosiphowedge and is slightly and evenly concave. The sides of the triangle bulge laterally and its apex is situated in the dorso-ventral median line, where the endosiphuncular lining is thinnest.

A silicified fragment (a paratype) of an adapical portion of a siphuncle is of particular interest in that it shows traces of endosiphoblades. The fragment is only 23 mm. long and its greatest dorso-ventral diameter is 17 mm., the corresponding lateral diameter 19 mm. On the surface faint traces of annulations, sloping at an angle of about 30°, are recognizable. The "wall" of the siphuncle is slightly less than 2 mm. thick; the interior is hollow; and there is no trace of an endosiphowedge. The interior is subdivided into three compartments by three vertical thin walls of which one is approximately in the dorso-ventral plane of the siphuncle on the dorsal side of the specimen; near the dorsal side it splits into two diverging lamellae. Near the center of the siphuncle this wall is met by the two other walls which diverge from it on either side at an angle of about 115°. Of the three compartments of the siphuncle the largest is thus situated ventrally and the two smaller ones are placed dorso-laterally and are of equal size. The walls separating them meet at a point slightly dorsad of the center of the siphuncle.

These structures are comparable to the endosiphoblades of *Nanno*, *Proterocameroceras*, and others, first described by Holm and by Ruedemann. A more detailed discussion of these structures has been given above.

Holotype—73×2, and paratype, 73×16, Geological Survey. Mines Department, Hobart, Tasmania.

Remarks—*Manchuroceras steanei* differs from all Asiatic species of the genus in its smaller size, the diameter of most species being between one-third and one-half larger. *M. yenchouchengense* Obata (1939) has a similar lateral diameter, but is more strongly compressed in cross section and its dorso-ventral diameter is greater. Also, most Asiatic species have a blunter apex, though the apical end of *M. kobayashii*

Obata seems almost as acute as that of *M. careyi*. *M. excavatum*, the other Tasmanian species, described below, is distinguished mainly by the very much lower angle at which the annulations slope dorsad from the ventral side, but also by the cross section of the endocone and by the distribution of the endosiphosheaths.

MANCHUROCERAS EXCAVATUM
Teichert, n. sp.
Plate 58, figures 1–3

This species is based on part of an internal mould of a siphuncle which is 35.2 mm. long and entirely straight. The apex is acutely pointed and from there the diameter increases rapidly until at a distance of 13 mm. the dorso-ventral diameter is 13.5 mm. while the lateral diameter is 14.0 mm. At a distance of 29 mm. from the apex the lateral diameter has increased to 29.5, mm., while the dorso-ventral diameter cannot be accurately measured in this place.

The surface of the siphuncle is covered with annulations, partly rounded, partly sharp-crested (probably depending on the state of preservation). There are about eight of them in a length equal to the diameter of the siphuncle. Along the ventral side there is a smooth zone, indicating the belt along which the siphuncle was in contact with the ventral wall of the conch. This smooth zone increases from a width of 2.5 mm. near the apex to 10 mm. at a distance of about 15 mm. from the apex. From this zone the annulations slope dorsad across the lateral sides of the siphuncle at an angle of about 10°.

The endocone tapers gradually and is very deep, extending to within about 8 mm. of the apex of the siphuncle. Its cross section at the adoral end of the specimen is somewhat elliptical, being slightly depressed in the dorso-ventral axis of the specimen. Its ventral side is flattened along the surface of the endosiphowedge. The calcitic lining between the endocone and the wall of the siphuncle, representing the space originally taken up by the endosiphosheaths, is fairly regular. Its width on the dorsal side of the siphuncle is 4 mm., along the lateral face of the siphuncle it is 3.7 mm. The width on the ventral side cannot be measured since this part of the specimen is broken.

Holotype—73×17, Geological Survey, Mines Department, Hobart, Tasmania.

Remarks—As in the case of *M. steanei* the difference of the present species from Asiatic representatives of *Manchuroceras* is chiefly one of size, the Tasmanian species being smaller. The differences from *M. steanei* as already indicated, are in the much lower angle of obliqueness of the annulations; in the cross section of the endocone which is subtriangular in *M. steanei*, elliptical in *M. excavatum*; and finally in the distribution of the material replacing the endosiphosheaths which in *M. excavatum* is thickest along the dorsal side.

Genus UTOCERAS Ulrich,
Foerste, and Miller
UTOCERAS ? sp.
Plate 58, figures 13–15

This is a fragment of a siphuncle which is 33.5 mm. long. At the adapical end the dorso-ventral diameter is 25.0 mm., the lateral diameter 15.2 mm. At the adoral end the corresponding figures are 26.7 mm. and 16.6 mm. The specimen is slightly curved and bears weak annulations on the surface which slope at a low angle from the ventral towards the dorsal side. Along the dorsal side of the specimen they are about 5 mm. apart, whereas along the ventral side the distance between them is little more than 3 mm.

At the adoral end the interior of the siphuncle is filled almost entirely with rock matrix; only along the dorsal side is there a layer of crystalline calcite which, in the dorso-ventral section, has a maximum thickness of about 4.2 mm. At the adapical end the siphuncle is entirely filled with crystalline calcite, a condition which indicates a very abrupt tapering of the endocone.

Holotype—73×4, Geological Survey, Mines Department, Hobart, Tasmania.

Remarks—Owing to its fragmentary nature the true affinities of this specimen remain in doubt. It resembles the known representatives of *Utoceras* in its slow rate of orad expansion in which respect it is definitely distinct from *Piloceras*, and also in the weakness of its annulations. It may differ from true *Utoceras* in being more strongly curved and possessing a more strongly compressed cross section, although

the latter distinction is probably unimportant. *Utoceras* has so far been known only from the Manitou limestone of central Colorado.

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NEW ORDOVICIAN NAUTILOIDS FROM NEW YORK

ROUSSEAU H. FLOWER
New York State Museum

ABSTRACT—Three new cephalopods from the New York Ordovician are described and illustrated, *Pachecdyceras murale*, n. gen., n. sp., of the Chazyan, *Allumettoceras giganteum* from the lower Trenton and *Fremontoceras jewetti* from the Middle Trenton.

ONE of the outstanding fossil collections of the last century was that amassed by Col. Ezekiel Jewett, nearly a hundred years ago. This material, justly famous for the number of unique specimens which it contained, supplied Hall with a number of types for his Paleontology of New York. Some of the material found its way into Hall's collection, part of which remains at the New York State Museum, but the bulk of the collection remained intact. In the early days of Cornell University it was purchased by Ezra Cornell, reputedly for the sum of $10,000, and served as the nucleus of the fossil collections of Cornell University. In the process of the identification of the cephalopods in this collection, a number of undescribed forms were found. Three species from the Ordovician, all of more than usual interest, are described in the present paper. Silurian and Devonian species will be described at another time.

Genus PACHECDYCERAS Flower, n. gen.

Genotype: PACHECDYCERAS MURALE Flower, n. sp.

Conch orthoconic, the expansion decreasing on the adoral part of the living chamber, giving the shell a fusiform appearance. Section depressed, venter strongly flattened, dorsum broadly arched, sides strongly rounded. Suture with a prominent deep ventral lobe, and either transverse dorsally or with a broad faint dorsal lobe. Septum moderately deep, curved more strongly ventrally than dorsally. Siphuncle between the center and the venter, placed at the point of greatest depth of the septum. Living chamber thickened internally and longitudinally sulcate. The internal mold presents an aspect not unlike that of the siphuncle of *Chihlioceras* Grabau. The ventral wall is strongly thickened, with two ridges separated by a median sulcus. The dorsum exhibits a median and two lateral pairs of sulci. Surface without any definite lines of growth. The genotype shows a faint linear external depression on the middorsum.

Discussion.—The assymetrical vertical curvature of the septum, the lobation of the sutures, the position of the siphuncle and the strong flattening of the cross section, so that it is nearly semicircular, are features which this genus shares with *Ecdyceras*. The genotype occurs in essentially the same beds which yielded the type of this genus. However, the two are obviously specifically distinct, for the thickened living chamber is a gerontic feature, and is attained in a specimen of *P. murale* which is much smaller than *Ecdyceras sinuiferum*. Happily the types of *Ecdyceras* were broken in such a way as to show that no similar thickening of the shell wall occurs there. Indeed, one of the types was sectioned vertically, the section passing well orad of the base of the living chamber. The thickening of the interior of the shell wall in this way is not known in any other nautiloid living chamber. Such a peculiar feature is considered sufficient to require setting this species in a new genus distinct from *Ecdyceras*, to which it is unquestionably very closely allied.

The presence of such peculiar features within the living chamber of a shell which is properly placed with the Mixochoanites immediately raises the question as to whether septa rather than a thickening of the shell wall can be involved. The calcite bordering the internal mold of the living chamber is coarse grained centrally, but becomes very fine grained next to the outside of the shell and also next to the interior. Such preservation might easily occur in a camera bounded on the interior by a septum projecting orad

into the living chamber after the manner of that in *Ascoceras*. This interpretation has to be rejected, for the basal suture of the living chamber is clearly preserved and relatively simple. Further, the greatest thickening of the calcite occurs in this form on the venter and not on the dorsum. The extreme apical part of the internal mold on the ventral side shows that the thickening of the shell is vestigial there, but becomes more prominent as it is traced orad. The thickening is reduced laterally but dies out gradually; any septum would leave a clear indication of a suture. It is not known how far orad in the living chamber this thickening of the wall may persist. However, the outer third of the living chamber is very slightly crushed, and the clear preservation of the basal two-thirds is probably the result of the extra support which this internal thickening provides.

The ventral aspect of the internal mold of this living chamber is strongly reminiscent of the internal mold of the siphuncle of *Chihlioceras* Grabau. That the shell is not a piloceroid siphuncle is shown by the clear preservation of the septum and the siphuncle at the base of the type.

The genus is regarded as a member of the family Hebetoceratidae (Flower, 1941), of the Mixochoanites, very closely related to *Ecdyceras*.

PACHECDYCERAS MURALE
Flower, n. sp.
Plate 59, figures 2, 3, 6

The type consists of a straight living chamber, expanding moderately rapidly and faintly fusiform. The cross section of the shell is depressed, the venter strongly flattened, the dorsum arched, the sides narrowly rounded. At the base, the width is 18 mm., the height 15 mm. These expand in 60 mm. to 29 mm. and 24 mm. The maximum length of the living chamber is 84 mm., the last 35 mm. being less rapidly expanded than the basal portion.

The phragmocone is known only from the septum preserved at the base of the living chamber. The suture is transverse dorsally and laterally, but describes a broad lobe over the flattened ventral face. The suture develops a very faint dorsal lobe and a deep prominent ventral lobe separated by lateral saddles. The septum is 7 mm. deep, measuring from the lateral part of the suture where its width is 17 mm.; its height 15 mm. Curvature of the suture is much stronger ventrally than dorsally. The siphuncle, 1.5 mm. in diameter at the septal foramen, is 2 mm. from the venter, ventrad of the point of greatest depth of the septum.

The wall of the living chamber is thickened internally over the basal half, possibly the basal two-thirds of the shell. No thickening appears at the septum at the base of the living chamber, but directly orad of the septum the wall of the living chamber becomes increasingly thickened over its basal third. The pattern produced on the internal mold may well be seen from the photographs, and is illustrated diagrammatically in cross section in figure 1.

FIG. 1—Diagrammatic cross section of *Pachecdyceras murale* one-third the distance from the base of the living chamber to the aperture, showing the pair of flat ventral sulci separated by a median groove, and the three pairs of dorsal sulci, also the emargination of the shell of the dorsal exterior. Ventrolaterally no internal thickening of the shell occurs.

No ventrolateral thickening of the shell wall occurs. However, the ventral wall is greatly thickened into two longitudinal lobes separated by a narrow rounded groove. Of the dorsal grooves, the median one is the strongest, and the pair flanking the median groove is relatively faint. Conditions of preservation made it seem inadvisable to expose more of the internal mold to show the thickening farther orad. The thickening must continue beyond the point where it is exposed, and probably occupies the basal two-thirds of the shell, for the anterior third of the living chamber shows evidence of crushing which contrasts strongly with the clear preservation of the basal portion.

The surface of the shell is rather rough, but shows no clear lines of growth or other markings, except a mid-dorsal line depression.

Discussion.—The essential features by

which this species can be recognized are embodied in the generic description. No other straight nautiloid is known exhibiting such thickening of the interior of the living chamber. Further study of this form is needed, particularly in reference to the adoral modification of the internal thickening of the living chamber, and also in reference to the structure of the phragmocone. Both investigations must await further material. The species is known only from the type. An inadequate fragment collected by the writer in the Middle Chazyan southwest of Chazy, N. Y. is probably conspecific, but is inadequate for certain identification.

Holotype.—Cornell University, from the Jewett collection.

Occurrence.—From the Chazy limestone, Chazy, N. Y.

ALLUMETTOCERAS GIGANTEUM
Flower, n. sp.
Plate 59, figures 1, 4

Conch straight, strongly depressed, the venter nearly flat, the sides strongly rounded. The dorsum, incompletely known, being largely lost by weathering, was apparently somewhat less strongly flattened than the venter. The type and only known specimen is 68 mm. in length, expanding in width from 34 mm. to 38 mm. in a length of 40 mm. The height is 18 mm. where the width is 38 mm.

Sutures forming broad lobes in midventral region, rising laterally, and becoming transverse at the ventro-lateral margins, thence sloping apicad forming a broader more uniform and slightly shallower lobe occupying the entire dorsum. The septum shows slight vertical curvature, but has a lateral depth of 8 mm. where it is 38 mm. wide, equal to the length of two camerae. The camerae in the basal part occur ten in 28 mm., but adorally they become slightly shortened gerontically, the last eight occupying 17 mm.

The septal foramen is depressed in section, 3 mm. from the venter, 2 mm. high, 3 mm. wide, the section of the shell being 32 mm. wide and 15 mm. high. The base of the specimen was sectioned horizontally to expose the siphuncle. The segments are subspherical, the greatest width lying slightly orad of the middle of the segment. The septal necks are short, recurved, free. A segment 8 mm. long expands from 1.2 mm. to 2.2 mm. within the camerae. No accessory deposits are developed in the siphuncle or camerae.

The type retains the basal 20 mm. of a living chamber which is obviously very incomplete.

Discussion.—This species is of particular interest in that the features exhibited by the exterior of the internal mold would permit it to be placed in two genera, *Lambeoceras* and *Allumettoceras*. It is not quite typical of either. It differs from typical *Lambeoceras* in that the sides are strongly rounded but not subangular in cross section. In this it resembles *Allumettoceras*, but differs from typical members of this genus in its large size, the relatively large septal foramen, the transverse condition assumed by the sutures as they approach the sides of the ventral face, and the prominence of lobes on the dorsum. However, a section of the siphuncle shows that the segments are relatively small, subspherical, and are typical of *Allumettoceras*. The siphuncle of *Lambeoceras* is much more broadly expanded between the septa, with the connecting rings broadly adnate and the brims recumbent or nearly so. This species is of particular interest in that it is a member of the Allumettoceratidae (Flower, 1946, p. 215), which approaches very closely in form to *Lambeoceras*. The broadly expanded siphuncle is typical of *Allumettoceras*, and I have retained it in this genus, though the sinuous ventral sutures and relatively prominent lobes of the dorsum might well be considered sufficient grounds for the erection of a new genus for this species. I have not done so, largely because it does not seem that a new generic name would serve any useful function. *Rasmussenoceras* Foerste (1933) was erected for a species, formerly assigned to *Lambeoceras*, which showed, by its small and slender siphuncle, that it was allied instead to *Tripteroceras*. Flower (1946, pp. 216, 220) revised the genus and described a Cincinnatian species which showed a remarkable recapitulation of the triangular cross section of a *Tripteroceras* in its early growth stages. Our present species of *Allumettoceras* does not seem to be closely allied to either *Tripteroceras* or *Rasmussenoceras*. Both genera show strong angulation of the cross section laterally, and in both the siphuncle has become very small,

marginal, and its segments are so slender as to be suborthochoanitic rather than properly cyrtochoanitic. Although these genera are regarded as derived from *Allumettoceras*, they developed from quite another group of species within the genus, in which the segments of the siphuncle are relatively slender and the sutures do not tend to develop a sinuous pattern on the venter of the shell.

The type, when sectioned, at first failed to show any trace of the connecting rings upon the surface of the section. The surface was then etched with moderately dilute hydrochloric acid, and the surface allowed to dry. The rings showed faint light reflections upon the dry surface, and by suitable adjustment of the light were photographed effectively. Our illustration of the section is unretouched. This technique is occasionally effective in bringing out the connecting rings where the conditions of preservation are poor, and may reveal essential structural details in sections which show only the faintest indication of the siphuncle outline on polished surfaces. I have found it useful occasionally in treating the siphuncles of cephalopods from the Schoharie grit.

Holotype.—Cornell University, no. 8113. From the Jewett collection.

Occurrence.—From "near the Black River, Newport, N. Y." The lithology, a black limestone replete with fragments of crinoid stems, is indicative of the Trenton. At Newport the Black River is represented only by the Lowville, which is succeeded by a few feet of the Rockland division of the Trenton. It is reasonable to assume, though it is not certain, that the species is from the Rockland. Overlying beds regarded as of Hull age, are barren of cephalopods.

FREMONTOCERAS JEWETTI
Flower, n. sp.
Plate 59, figures 5, 7

Type a cyrtoconic portion of a shell which may, when complete, have been a gyroceracone. The type and only known specimen consists of a living chamber and the adoral portion of a phragmocone. Shell with a radius of curvature of 105 mm., ventral length 115 mm., dorsal length 77 mm. Living chamber 45 mm. long dorsally, 85 mm. ventrally, width increasing from 47 mm. to 50 mm., height increasing from 34 mm. to 40 mm. Aperture transverse dorsally and laterally, lost by weathering on the venter. Probably a hyponomic sinus was present. Cross section depressed, rounded, the venter slightly more flattened than the dorsum. The septum at the base of the type is 32 mm. high, 38 mm. wide, and 8 mm. deep. Curvature of the septum is stronger ventrally than dorsally. The septal foramen is 2 mm. high, 8 mm. from the venter, being between the venter and the center. The sutures are oblique, sloping apicad from dorsum to venter, but are without lobation. Owing to the obliquity, broad lobes are present ventrally and saddles dorsally. The sutures are obscure ventrally. Laterally the three basal camerae occupy a length of 18 mm. The adoral camerae are faint but seven appear to be present, the last two gerontically shortened, indicating that the shell had attained maturity. No trace of the surface features remains.

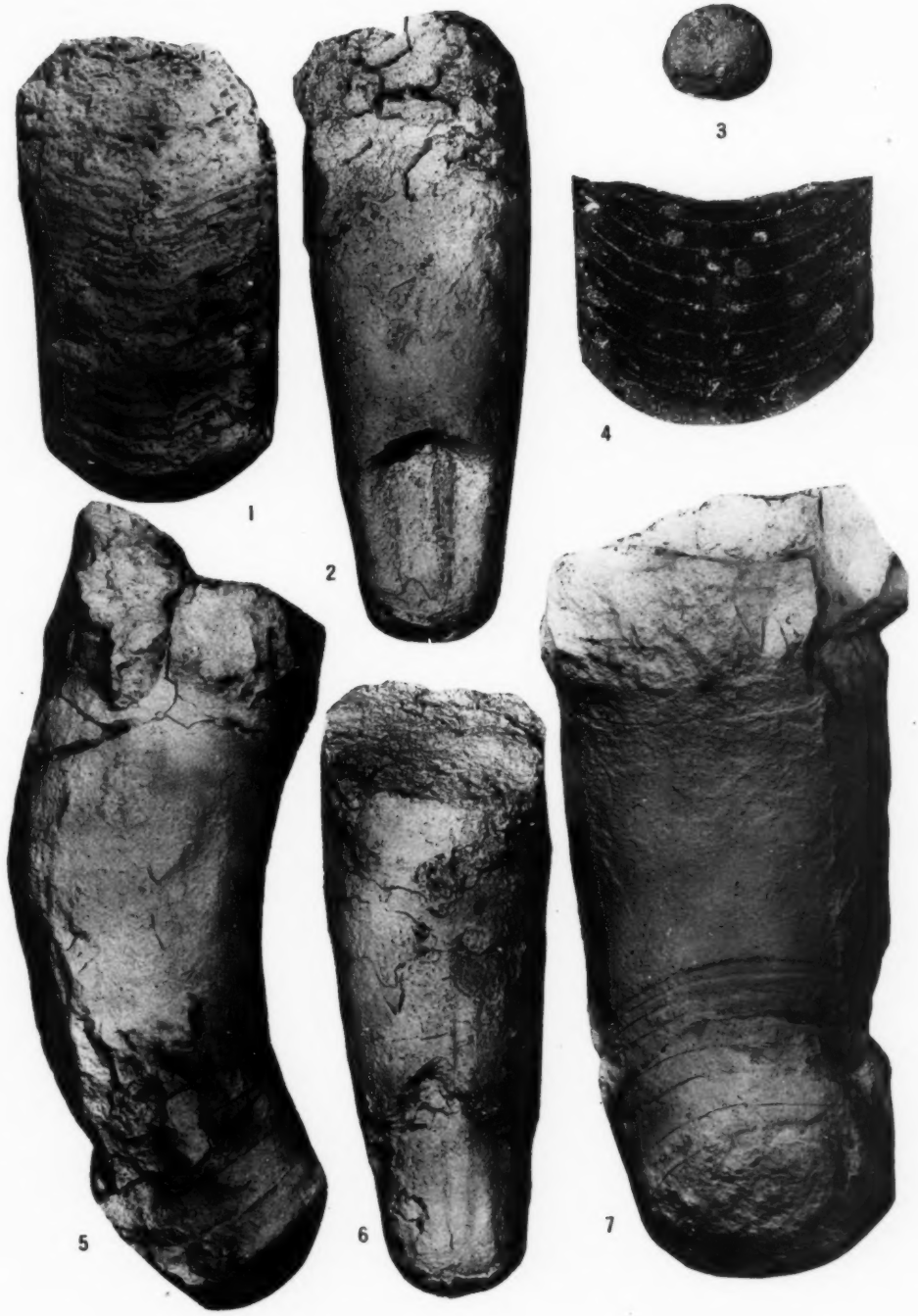
Discussion.—This species is the largest of the cyrtocones of the New York Trenton, and no forms yet described from the Trenton of New York, Ontario or Quebec are closely comparable. The deep septum, the position of the siphuncle between the center and the venter, the slightly flattened venter, indicate that this species is assignable to the Ordovician Apsidoceratidae (Flower, 1943). It is, however, a rather generalized member of the family and does not fit perfectly into the generic divisions which have been based upon younger and more specialized species. The poor development of ventral lobes and

EXPLANATION OF PLATE 59

FIGS. *1, 4—Allumettoceras giganteum* Flower, n. sp. *1*, holotype, ventral view, ×.8; *4*, horizontal section of base of type, ×1.5 showing siphuncle. Cornell Univ. no. 8113. Trenton limestone, Newport, N. Y. (p. 431)

2–3, 6—Pachecdyceras murale Flower, n. sp. *2*, ventral, *3*, apical and *6*, dorsal views of holotype, ×1. Cornell Univ. Chazy limestone, Chazy, N. Y. (p. 430)

5, 7—Fremontoceras jewetti Flower, n. sp. Holotype, ×¾; *5*, lateral and *7*, dorsal views. Cornell Univ. no. 8108. Trenton limestone, Trenton Falls, N. Y. (p. 432)



Flower, New York Ordovician Nautiloids

the ventral face set this form apart from typical *Apsidoceras*. The generalized cross section is perhaps more closely approached in *Deckeroceras*, but in that genus the venter is more definitely flattened, and the living chamber becomes faintly gibbous.

The known part of this shell is so slender that the complete conch may have been a gyroceracone similar to *Fremontoceras*. In the poor development of faces and small size, this form is generalized both in relation to the genotype from the Fremont limestone of Colorado, and to an undescribed form from the upper Trenton of Montreal. The species is assigned to *Fremontoceras*, as it seems to be more similar to that than other genera of the Apsidoceratidae. It is very doubtful whether the whorls were in contact, and the section is atypically rounded. Nevertheless, it seems wiser to place this form in *Fremontoceras*, than to erect a new genus for its reception. *Deckeroceras* Foerste (1933) is also comparable in that its section and sutures are somewhat generalized, but the mature living chambers are faintly gibbous.

The species is known only from the type, a shell which is incomplete basally and very badly weathered on the venter. The form is evidently very rare, as I have had no indication of it in other collections from the Trenton limestone.

Discussion.—This is distinctive among the Trenton cephalopods in its great size; no other cyrtoconic shell is known in the New York Trenton which approximates it in dimensions. The rather generalized cross section and sutures cause this shell to suggest both the Valcouroceratidae and the Apsidoceratidae in its affinities. The lack of a compressed condition, a definitely angled venter, and the depth of the septum are at variance with the Valcouroceratidae, and agree with features shown in the Apsidoceratidae. The slight curvature of the shell suggests that the form was a cyrtoceracone rather than a gyroceracone. In this respect the shell is more similar to *Deckeroceras* than to *Fremontoceras*. However, there is no gibbosity of the living chamber, which is atypical of *Deckeroceras*.

Holotype.—Cornell University, 8108, from the Jewett collection.

Occurrence.—Trenton limestone, Trenton Falls, New York. Evidently from the Middle Trenton Sherman Falls limestone.

MANUSCRIPT RECEIVED JANUARY 8, 1947

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JOURNAL OF PALEONTOLOGY, VOL. 21, NO. 5, PP. 434–435, PL. 60, SEPTEMBER 1947

CAMBRIAN BRYOZOA

MADELEINE A. FRITZ
Royal Ontario Museum of Palaeontology, Toronto

INTRODUCTION

ALTHOUGH Bryozoa are among the most prolific fossil groups in the Middle Ordovician period and thereafter in the Palaeozoic, no trace of their remains has been reported until the present time from the Cambrian of North America. Even in the Lower Ordovician they are almost unknown. Dr. R. S. Bassler (personal correspondence) found a "*Nicholsonella*-like form" in rocks of Canadian age, this being the oldest authenticated representative of the group hitherto reported. E. S. Cobbold has reported three small "polyzoon" specimens from the Lower Cambrian of England but no microscopic sections were prepared to actually prove their bryozoon identity.

In the summer of 1945 O. A. Erdman of the Geological Survey of Canada, while working in the First Range of the Rocky Mountains in Alberta, brought back samples of fossiliferous rock which were identified as Cambrian on the basis of the trilobites. Upon closer examination of the material Dr. A. E. Wilson noticed several fragmentary specimens which appeared to resemble Bryozoa. The specimens, which were forwarded to me for study, have afforded the information set forth in this paper.

The material was collected from the Cripple Creek area. This area is situated in the Ram Range of the Foothills in Latitude 52.07°, Longitude 116°. It is about 25 miles south of Brazeau Station on the Canadian National Railway. Two fossil localities are represented. They are designated as C 486 and E 1441.

Two pieces of highly fossiliferous limestone, one from each of the above mentioned localities, were submitted. The fossils consist, for the most part, of comminuted remains of trilobites which are, in the main, unrecognizable. Two specimens, however, from C 486 are identifiable. One, figure 1(1), represents the cephalon of *Elvinia* sp.; the other, figure 1(2), the cranidium of *Bynumia* cf. *B. elegans* Resser. The presence of these trilobites strongly suggests Cambrian, possibly upper Cambrian, as the age of the rock.

Closely associated with these specimens and almost touching the example of *B.* cf. *elegans* was a small domelike mass with porous surface, which had the appearance of a bryozoan or a microscopic coral. Figure 1(3) shows it before sectioning. Unfortunately only one satisfactory section, a tangential, was obtained.

At E 1441, among similar trilobite fragments, a second colony apparently of about the same dimensions, though flatter, was exposed. It was broken in such a way that a natural vertical section was revealed. A microscopic section parallel to this surface was obtained.

DETAILED DESCRIPTION OF SPECIMENS

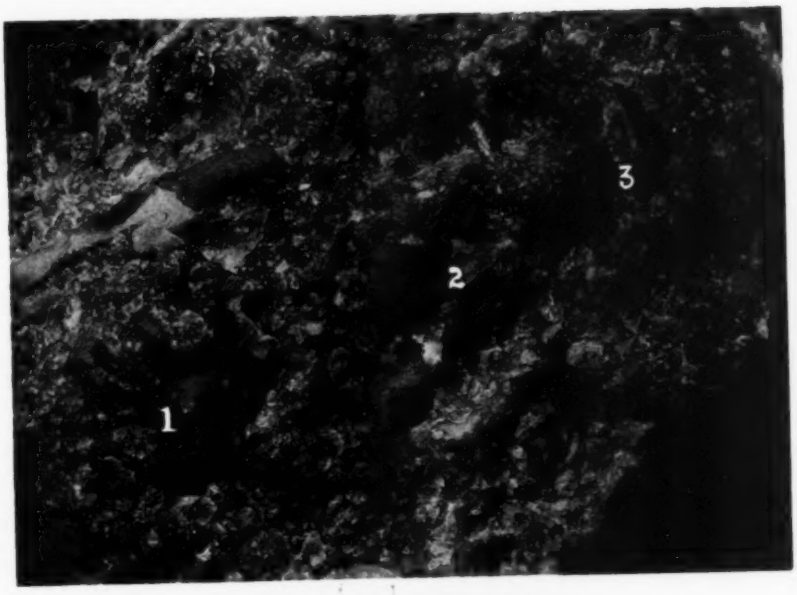
It is unfortunate that it was not possible to obtain from each specimen both a tangential and a vertical section. A tangential from one specimen and a vertical from the other leaves much to be desired, as all workers on Bryozoa will agree. There is no real assurance that the two specimens represent the same species or even the same genus. They do appear, however, to be related. In order to give a definite status to these supposed Bryozoa it is my intention to create

EXPLANATION OF PLATE 60

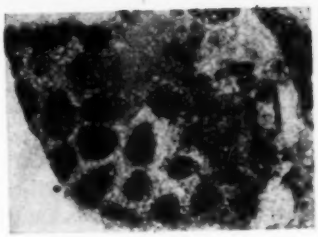
FIG. *1*—Slab of limestone ×3, showing (1) *Elvinia* sp., (2) *Bynumia* cf. *elegans* Resser, (3) Zoarium of *Archaeotrypa secunda* Fritz, n. sp. (p. 435)

2—*Archaeotrypa secunda* Fritz, n. sp. Holotype, ×13, tangential section, No. 9480, Geological Survey of Canada collections. (p. 435)

3, 4—*Archaeotrypa prima* Fritz, n. sp. *3*, holotype ×13, vertical section, No. 9479, Geological Survey of Canada collections. *4*, outline drawing of zooecia in same section. (p. 435)



1



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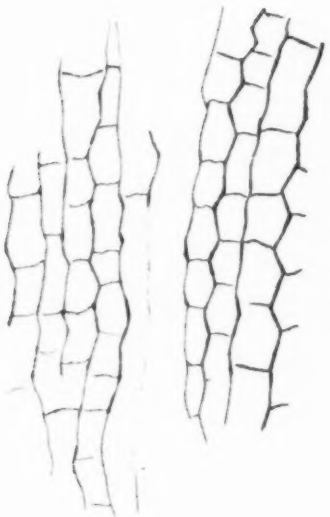

4

Fritz, Cambrian Bryozoa

UNIV. OF MICH.

the genus *Archaeotrypa* to receive these forms. They are here described as separate species, though it may be necessary to reclassify the present material should more specimens be found.

Genus Archaeotrypa
Fritz, nov. gen.

Zoarium small, flat, or dome-shaped. Walls uniformly thin in vertical section, distinctly zig-zag in places. Straight diaphragms developed at regular intervals. Lunarium not clearly marked but suggested in tangential section.

Genotype, A. prima
Fritz, n. sp.

The two specific descriptions that follow are of necessity brief owing to the inadequacy of the material available for study at the present time.

Archaeotrypa prima
Fritz, n. sp.
Plate 60, figures 3, 4

External features.—Zoarium a flattened mass, measuring at least 12 mm. across and 9 mm. in thickness. Surface not observed.

Vertical section.—Most of the information concerning this specimen has been obtained from one section, in which crystallization has destroyed much of the detail. Zooecia 6 in 2 mm. Tubes long, straight, and thin-walled throughout the entire length observed. Certain walls zig-zag. Straight diaphragms at regular intervals, spaced about two tube-diameters apart. Mesopores lacking.

Remarks.—This species bears a resemblance to the cyclostomatous bryozoan *Crepipora perampla* Ulrich from the Trenton of Minnesota, particularly in the long, thin-walled, uniformly diaphragmed tubes. The walls, however, show no crenulation as in *C. perampla*, and the characteristic zig-zag appearance is not present in that species.

Although no tangential section was obtained, part of the vertical section reveals several structures that suggest zooecia cut tangentially, as well as a group of small macular cells. The zooecialike openings show an irregular, wavy outline not unlike that seen in *Crepipora perampla*. This waviness suggests the presence of lunaria.

Locality.—E. 1441.

Type.—Holotype 9479, Geological Survey Canada collections. Microscopic slide only.

Archaeotrypa secunda
Fritz, n. sp.
Plate 60, figures 1(3), 2

External features.—Zoarium dome-shaped, 15 mm. in diameter, thickness not more than 3 mm. at center. Surface apparently smooth.

Tangential section.—Only about a dozen zooecia shown, 5 in 2 mm., subpolygonal in outline, certain cells elongated. Walls completely crystallized so that it is difficult to decide whether a lunarium is present; thickness of walls also obscured.

Locality.—C. 486.

Type.—Holotype 9480, Geological Survey Canada collections. Microscopic slide only.

Manuscript received September 23, 1946

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JOURNAL OF PALEONTOLOGY, VOL. 21, NO. 5, PP. 436–452, PLS. 61–63, SEPTEMBER 1947

A REVISION OF THE BRACHIOPODA OF THE LOWER DEVONIAN STRATA OF REEFTON, NEW ZEALAND

ROBIN S. ALLAN
Canterbury University College, Christchurch, New Zealand

ABSTRACT—The brachiopod fauna of the Lower Devonian mudstones at Reefton, New Zealand, has been restudied at the U. S. National Museum during a visit to the United States of America. Four new genera and five new species are described and illustrated. The age and origin of the Reefton fauna are briefly discussed.

INTRODUCTION

THE FAUNA of the Reefton Beds, at Lankey Creek, Reefton, New Zealand was described by the writer in 1935. Since that date J. Shirley (1938) has monographed the fauna of the co-aeval Baton River beds of Nelson, and new collections have been made at Reefton. K. E. Caster (1939) and P. E. Cloud, Jr. (1942) have made passing comments concerning some of the determinations made by Shirley and the writer. Some of these points were touched on by the writer (Allan, 1942) who has also published an index to the Devonian faunas of New Zealand (Allan, 1945).

This study has been carried out at the United States National Museum, Washington, D. C., during a short visit to the United States of America. I am under a deep sense of obligation to Dr. A. Wetmore, Secretary of the Smithsonian Institution, and to Dr. R. S. Bassler, Head Curator of Geology at the U. S. National Museum, for permission to work in the Institution under their charge.

I am grateful to Dr. G. A. Cooper, Curator of the Division of Invertebrate Paleontology and Paleobotany, for working facilities in his Division. It is a pleasure and a duty to record my appreciation of the manner in which the material resources and collections of this great museum are made available to overseas students. Dr. G. A. Cooper has built up a truly magnificent collection of Brachiopoda, undoubtedly the finest in existence. The wealth of material available for comparative purposes, and the perfection of so many of the specimens, make this rapidly growing collection the envy of all students of the brachiopods who have been fortunate enough to see it.

During my visit I have had the advantage of daily discussion with Dr. Cooper who has aided me generously with the fruits of his experience and his encyclopedic knowledge of the Brachiopoda. His stimulating suggestions have been invaluable. I find it difficult to express my thanks in adequate terms.

SYSTEMATIC DESCRIPTIONS

Family RHIPIDOMELLIDAE Schuchert, 1913

Genus REEFTONIA Allan, n. gen.

Genotype, *Reeftonia marwicki* n. sp.

Description: Exterior—Subquadrate to transversely subelliptical, hinge line straight, narrower than the greatest width of the shell; cardinal extremities obtusely rounded. Lateral profile subplanoconvex; anterior commissure rectimarginate to incipiently sulcate; dorsal sulcus distinct, extending from umbo to anterior margin. Ventral interarea longer than the dorsal, apsacline. Beak curved, umbo swollen; delthyrium open. Dorsal interarea orthocline; notothyrium partly closed by the cardinal process. Ornamentation multicostellate, increasing by division.

Ventral interior—Delthyrial cavity deep; teeth strong, ridge-like, supported by massive dental plates; with deep crural fossettes on the inner faces of the teeth; dental plates hardly diverging but produced forward as low carinae to bound the lateral margins of the muscle field. This is impressed, extending forward slightly more than half the length of the valve; diductor scars elongate, semiflabellate; adductor scars oval, small, completely surrounded by the diductors and placed in a posteromedian position; the whole muscle field divided medially by a low septum.

Dorsal interior—Cardinalia confined, sockets wide, deep, without fulcral plates; brachiophores long, bluntly pointed, without end processes; cardinal process small, boss-like, undivided, shaft short, merging into a short, broadly rounded median ridge. Muscle field not impressed, subquadrate, division into posterior and anterior scars not clear.

Remarks.—Although endopunctae have not been seen (all the Reefton material is in the form of casts or moulds) this group clearly falls into the punctate Dalmanellacea. The absence of fulcral plates in the dorsal valve, and the fact that in the ventral valve the diductor scars completely enclose the adductor impressions, are the reasons for referring *Reeftonia* to the Rhipidomellidae rather than to the Dalmanellidae (as used by Schuchert and Cooper, 1932, pp. 119–124) or to the Schizophoriidae.

Reeftonia is distinct from the four genera which Schuchert and Cooper (1932, pp. 133–136) placed in the Rhipidomellidae. In *Rhipidomella* the dorsal valve has the greater convexity and the hinge line is narrow; in the dorsal valve the brachiophores carry sharp processes, and the cardinal process is large, with a lobate, ponderous myophore. In all these characters *Reeftonia* shows significant differences. *Reeftonia*, with its distinct ventral interareas, is easily separated from *Perditocardinia* in which the hinge line has narrowed to disappearance. *Platyorthis* differs in being planoconvex without dorsal sulcus, and in possessing a ponderous, ventrocentrally cleft cardinal process. *Thiemella* differs in the presence of a well marked ventral fold, and a ventral median septum which extends beyond the anterior ends of the diductor scars.

REEFTONIA MARWICKI Allan, n. sp.
Plate 63, figures 6–9

1935. *Proschizophoria* cf. *provulvaria* (Maurer): ALLAN, New Zealand Geol. Surv. Pal. Bull. no. 14, pp. 11–12, pl. 3, figs. 4, 7.

Remarks.—The characters of this species are given above in the generic diagnosis.

Holotype, the original of pl. 3, figure 7 (Allan, 1935), an internal mold of the dorsal valve, in the N. Z. Geological Survey Collection; paratypes, internal molds of the ventral valve, are in that Survey collection (the original of pl. 3, fig. 4); in the U. S. National Museum (Cat. No. 112107), and in the Allan Collection which also contains the figured examples of exteriors.

In 1945 the writer referred the Reefton fossil to *Schizophoria provulvaria* (Maurer) which Shirley (1938, p. 465, pl. 40, figs. 10–13) recorded from the Baton River Beds. In the Schizophoriidae, however, the ventral adductors are on a ridge which separates long, divergent diductors, and fulcral plates are present. The Reefton fossil, as Shirley pointed out, cannot be placed in either *Schizophoria* or *Proschizophoria*. The latter genus is unhappily named since it is not related to *Schizophoria* but falls into the family Dalmanellidae as used by Schuchert and Cooper. In *Proschizophoria* the ventral diductor scars do not envelop the adductor scars in front; and the cardinalia are ponderous, with a prominent cardinal process without expanded myophore. Both *Schizophoria* and *Proschizophoria* are resupinate, that is, the dorsal valve has the greater convexity.

Reeftonia marwicki was compared with *Orthis eminens* Hall (New York State Cab. Nat. Hist. Tenth Ann. Rept., 1857, p. 42, text-figs. 1–2, and Nat. Hist. New York, Pt. 6, Palaeont., Vol. 3, 1859, p. 167, pl. 11, figs. 7–14). This is a rare species, described from the Helderberg mountains of New York, which is difficult to place generically, so much so that it was not assigned to a genus in Schuchert and Cooper's monograph on the Orthoidea.

It was first decided to make *O. eminens* Hall the type of a new genus, and associate the Reefton fossil with it. However, in all the material available, including many ventral interiors collected in a recent field trip to Indian Springs, Maryland, where *O. eminens* Hall is not uncommon in strata of New Scotland age, it proved impossible to detect the position of the ventral adductor scars. There are differences in the cardinalia. For example, the cardinal process in *O. eminens* Hall is ventrocentrally cleft as in *Platyorthis*. In general shape, convexity and folding of the valves, nature of the hinge line, and in ornament the American fossil agrees closely with *Reeftonia*.

The species is named in compliment to Dr. J. Marwick, senior paleontologist on the New Zealand Geological Survey.

Family STROPHEODONTIDAE Caster, 1939

HISTORY OF NEW ZEALAND SPECIES

Allan (1935, pp. 12–13, pl. 1 figs. 9–10) described *Leptostrophia reeftonensis* n. sp. from Lankey's Gully, Reefton; and compared his species with the American Oriskany genotype, *L. magnifica* (Hall), and the European, *L. explanata* (Sowerby). In his report on the Baton River fauna Shirley (1938, p. 468) recorded *Leptostrophia explanata* (Sowerby). The following year K. E. Caster (1939, pp. 26–110) included a revision of the genera of the Stropheodontidae in his monograph "A Devonian fauna from Colombia." He commented (p. 86) on the Reefton species as follows:

> These are to my mind more like brachyprionids than leptostrophids. The subumbonal, or at least much restricted, denticles as well as the shallow sinus and fold belong rather with a *Brachyprion* or a *Douvillina* relative than with *Leptostrophia*. Corrugations such as those on *L. reeftonensis* are not present on shells from the Falklands or Argentina, to my knowledge. I see no striking points of similarity between the New Zealand material and *L. magnifica* and congeners which Allan stressed. I have, however, seen none of the Reefton material at first hand.

In a postscript to his study Caster (1939, pp. 182–184) commented on Shirley's record of *Leptostrophia explanata* (Sowerby) for Baton River, suggesting that it might be allied to his genus *Rhytistrophia* based on *Stropheodonta beckii* Hall. Allan (1942, p. 146), acting on Caster's lead, named the Baton River fossil *Rhytistrophia shirleyi*.

LEPTOSTROPHIA Hall and Clarke, 1892

1892. *Leptostrophia* HALL and CLARKE, Nat. Hist. New York, Palaeont., vol. 8, (1), p. 288.
1939. *Protoleptostrophia* CASTER, Bull. Amer. Paleont., 24, no. 83, (April 8), pp. 29 and 75–78. Type (by original designation) *Strophomena blainvillii* Billings, 1874, Pal. Fossils, pl. 2, p. 28, pl. 2, fig. 1; pl. 3, fig. 1. Gaspé, Oriskany.
1939. *Leptostrophia*, CASTER, Bull. Amer. Paleont., 24, no. 83, pp. 95–98.
1944. *Leptostrophia*, COOPER, in Shimer and Shrock, Index Fossils of North America, p. 341. Type designated by Schuchert, U. S. Geol. Surv. Bull., 87, 1897, p. 243) *Stropheodonta magnifica* Hall, 1857. Oriskany.

Selected synonymy of *Leptostrophia magnifica* (Hall) Plate 61, figure 5

1857. *Strophomena* (*Strophodonta*) *magnifica* HALL, New York State Cab. Nat. Hist., Tenth Ann. Rep. pp. 54–55. "In the Oriskany sandstone, Albany and Schoharie counties."
1859. *Strophodonta magnifica* HALL, Nat. Hist. New York, Palaeont., vol. 3 (1), pp. 414–415 and 482, pl. 93, fig. 4; pl. 95, fig. 8; pl. 95A, figs. 15–19. (Not pl. 94, figs. 2a–d = *magniventra* Hall.)
1892. *Stropheodonta* (*Leptostrophia*) *magnifica*, HALL, Nat. Hist. New York, Palaeont., vol. 8, (1), pl. 13, fig. 28. (Not fig. 27 = *magniventra* HALL.) Cumberland, Maryland.
1944. *Leptostrophia magnifica* (Hall): COOPER, in Shimer and Shrock, Index Foss. N. Amer., p. 341, pl. 131, figs. 18–19.

Remarks.—In view of Caster's comments concerning *Leptostrophia reeftonensis* Allan it became necessary to restudy the species, and to compare it with the genotypes of the various genera of the Stropheodontidae. This I have done, with some curious and interesting results.

The first result of this restudy is that the holotype of *L. reeftonensis* Allan, an internal mold of the ventral valve (pl. 1, fig. 10, of Bulletin No. 14) is a true *Leptostrophia*, but the paratype (pl. 1, fig. 9), an internal mold of the dorsal valve, was incorrectly associated with it, and represents a new genus described below. This confusion is partly responsible for the obscurity of Caster's comments on this species (Caster, 1939, p. 86).

It is curious that the same type of faulty association of ventral and dorsal valves occurred in connection with the description of the genotype of *Leptostrophia*. When *L. magnifica* was described in 1857 Hall apparently had not seen the interior of the dorsal valve. The same was stated to be true of *Strophomena* (*Strophodonta*) *magniventra* described by Hall on the same page (1857, p. 54) and from the same formation and localities. Even in 1859 (Nat Hist. New York, Palaeont., Vol. 3 pp. 411–412) Hall was uncertain of the dorsal valve in *L. magniventra*. At this time he associated with *L. magnifica* two molds of dorsal valves from the Oriskany of Albany County (1859, pl. 94, 2c–d). I have examined plaster casts of two molds in the U. S. National Museum (Cat. No. 5082a, b) and suggest that they should be associated with the shell figured in the same volume on pl. 95, figure 9 as *Strophodonta magniventra* Hall. Whether they are really *L. magniventra* (Hall) is another matter. The true dorsal valve of *L. magnifica* (Hall) has been illustrated by Cooper, in Shimer and Shrock, 1944, pl. 131, figure 19, and is

quite different. In view of the fact that *L. magnifica* (Hall) is the genotype, and since this faulty association of valves has already caused trouble, as I indicate below, it seems desirable to designate a ventral valve as lectotype of *L. magnifica* (Hall). As far as I can discover this has not previously been done. I now formally designate the original of plate 93, figure 4 (Hall, 1859) as lectotype of *Strophomena* (*Strophodonta*) *magnifica* Hall, 1857.

It seems reasonably clear that in Caster's diagnosis of *Leptostrophia* the characters of the dorsal interior are based partly on the genotype, and partly on another species, namely that figured by Hall (1859, pl. 94, figs. 2c–d), and here assumed to be *Strophodonta magniventra* Hall. For example his description (1939, pp. 96–97) of the ponderous tetrapartite cardinal process is from the genotype, but does not fit *S. magniventra* Hall; whereas his description of the muscle field is obviously based on *S. magniventra* Hall, and is not applicable to *Leptostrophia magnifica* (Hall). *S. magniventra* Hall appears to represent a distinct generic stock but the task of examining type material, and of working out relationships must be left to an American student.

The dorsal interior of *L. magnifica* is of the same general pattern as that in *Strophomena blainvillii* Billings, another Oriskany fossil, which Caster has made the genotype of *Protoleptostrophia*. I have prepared rubber replicas of topotypes of Billings' species in the U. S. National Museum. In *S. blainvillii* Billings there is no evidence of the subsidiary ridge which lies on either side of each prong of the cardinal process in the genotype of *Leptostrophia*. In Billings' species the buttresses which diverge from the posterior callus and separate the muscle field from the posterolateral strongly pustulose area, are more prominent, and the angle of divergence is greater than in *L. magnifica* (Hall). But, bearing in mind the gerontic features of *L. magnifica* (Hall), I must doubt whether the two groups are generically distinct.

For comparative purposes I include on pl. 61, figures 5–7, illustrations of rubber replicas of the dorsal interiors of *Leptostrophia magnifica* (Hall), "*Leptostrophia*" *magniventra* (Hall) and *Leptostrophia blainvillii* (Billings).

LEPTOSTROPHIA REEFTONENSIS
Allan, 1935
Plate 61, figure 2

1935. *Leptostrophia reeftonensis* ALLAN, New Zealand Geol. Surv. Pal. Bull. no. 14, pp. 12–13, pl. 1, fig. 10. (Not pl. 1, fig. 9 = *Maoristrophia neozelanica*, n. sp.)

Remarks.—As pointed out above the writer originally included two species under this heading. The holotype (pl. 1, fig. 10) is the internal mold of the ventral valve, and is the only specimen yet collected of this species. Consequently the dorsal valve is unknown. Caster's comments on this species, quoted above, refer mainly to the paratype, an interior of a dorsal valve, now placed in a new genus and species, and are, therefore, not pertinent here. However he no doubt included the holotype when he wrote "I see no striking points of similarity between the New Zealand material and *L. magnifica* and congeners which Allan stressed" (1939, p. 86). As far as the ventral valve is concerned, and my species is based on it alone, I must disagree. Restudy of the material has but served to strengthen the views expressed in 1935. For example, as I then pointed out, the ventral valve of *L. reeftonensis* is very similar to that of *L. magnifica* as figured by Hall in 1859 on pl. 95A, figure 17. Compare also pl. 61, figure 2 of this paper with pl. 13, figure 28 of Hall and Clarke, 1892. The Reefton fossil may also be compared with Clarke's illustrations of *L. magnifica* (Hall) and of the closely related *Leptostrophia irene* (Billings) (see Clarke, 1908, pl. 39, fig. 8—*L. irene* (Billings) and Clarke, 1909, pl. 20, fig. 20—*L. magnifica* (Hall)).

The similarities are so convincing that in spite of Caster's view I have no hesitation in regarding the Reefton species as congeneric with *Leptostrophia magnifica* (Hall). It will be possible to test this conclusion if future field work results in the finding of exteriors, and of dorsal interiors at Reefton.

By the use of liquid rubber it has been possible to make better impressions of the internal mold than formerly. Although the hinge of *L. reeftonensis* is imperfectly preserved it is now possible to state that the hinge crenulations extend well beyond the umbonal region, and the hinge was probably holocrenulate.

In North America the genotype and re-

lated species such as *Leptostrophia irene* (Billings) are widespread in the Oriskany sandstone of New York State, and in its correlatives, such as the Ridgeley sandstone of Maryland, the Glenerie limestone of Pennsylvania, and the Grand Grêve limestone of Maritime Canada. These beds form the upper part of the Deerpark stage of Cooper's classification of the Devonian of North America (Cooper et al., 1942). This stage is correlated with the Lower Coblenzian of Europe.

Genus MAORISTROPHIA Allan, n. gen.

Description.—Medium-sized plano-subconvex stropheodontids with narrow but distinct median fold in the ventral valve and a corresponding and similar sulcus in the dorsal valve; surface ornamented with costellae of essentially the same size; hinge crenulations in both valves restricted to a narrow zone on either side of the midline; dorsal cardinalia with well developed bifid, sessile cardinal process, strong socket-ridges (or socket-ridges fused with crural plates) and deep sockets margined posteriorly by the hinge crenulations; dorsal median septum strongly developed, fusing posteriorly with the cardinal process; muscle fields defined by faint carinae; ventral interior with diverging dental lamellae; median septum, low, narrow, merging posteriorly into a lozenge-shaped platform, separated by grooves from the posterior ends of the dental lamellae; adductors narrow and elongate, divided by the septum; diductors flabellate, faintly impressed and bounded by faint carinae which curve forward from the ends of the dental lamellae.

Genotype, *Maoristrophia neozelanica* Allan, n. sp.

MAORISTROPHIA NEOZELANICA
Allan, n. sp.
Plate 61, figures 1, 4, 8

1935. *Leptostrophia reeftonensis* ALLAN, New Zealand Geol. Survey Pal. Bull., no. 14, pp. 12–13, pl. 1, fig. 9 (not pl. 1, fig. 10).

Description.—Exterior of dorsal valve; shape subquadrate, cardinal extremities obtusely rounded or acutely pointed, being variable even on the two sides of a single specimen; valve almost flat, with a central shallow sulcus extending from the umbo to the anterior margin. Sculpture costellate, with sharp-angled ribs which increase by division and by intercalation; interspaces twice or three times the width of the ribs. Costellae and interspaces crossed by closely spaced concentric growth lines which are clearest on the interspaces. There are a few concentric growth stages producing varices.

Internal characters: These are included in the generic diagnosis above.

Dimensions: Holotype length 30 mm.; breadth 40 mm. Paratype (internal mold of the ventral valve) length 25 mm.; breadth 30 mm.

Holotype.—(formerly a paratype of *Leptostrophia reeftonensis* Allan) in the N. Z. Geological Survey Collection; paratypes (both valves) in the Allan Collection; paratypes (both valves) presented to the U. S. National Museum, Washington, D. C. (Cat. No. 112109).

Type locality.—Lankey's Creek, Reefton (Lower Devonian).

EXPLANATION OF PLATE 61

Unless otherwise stated the figures on the plates of this paper, which are unretouched, are natural size photographs of rubber replicas, and have been prepared by Dr. G. A. Cooper to whom my grateful thanks are due. NZGS refers to specimens in the collection of the New Zealand Geological Survey; USNM to those in the U. S. National Museum; AC to those in the Allan collection.

FIGS. *1, 4, 8*—*Maoristrophia neozelanica* Allan, n. sp. *1*, Holotype—dorsal interior of the paratype of *Leptostrophia reeftonensis* Allan. NZGS. *4*, Paratype—exterior of dorsal valve, AC. *8*, Paratype—ventral interior, AC. All from Lankey Creek, Reefton, New Zealand. (p. 440)

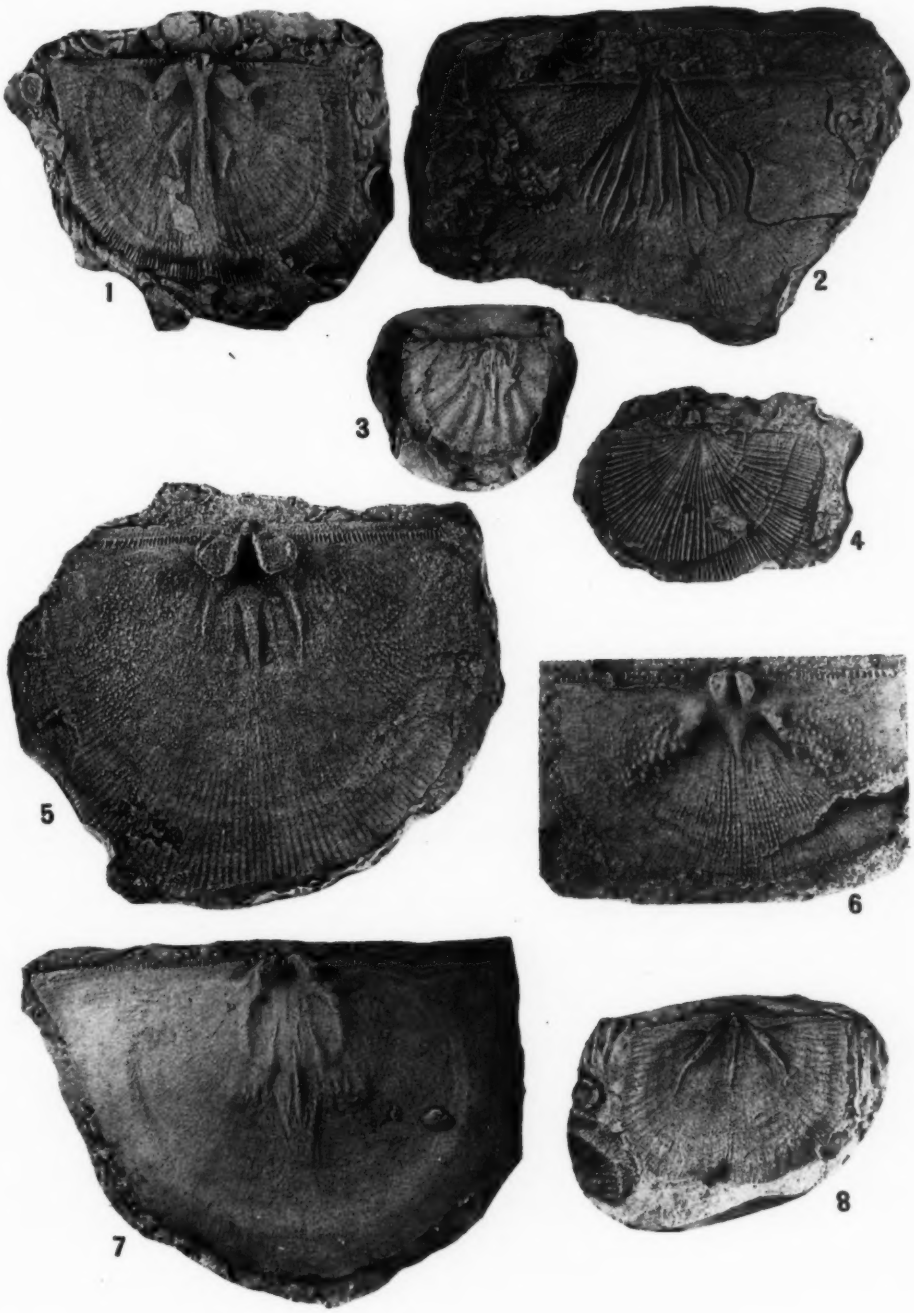
2—*Leptostrophia reeftonensis* Allan. Holotype—ventral interior, NZGS. Lankey Creek, Reefton. (p. 439)

3—*Stropheodonta huttoni* Allan, n. sp. Holotype—dorsal interior, NZGS. Lankey Creek, Reefton. (p. 441)

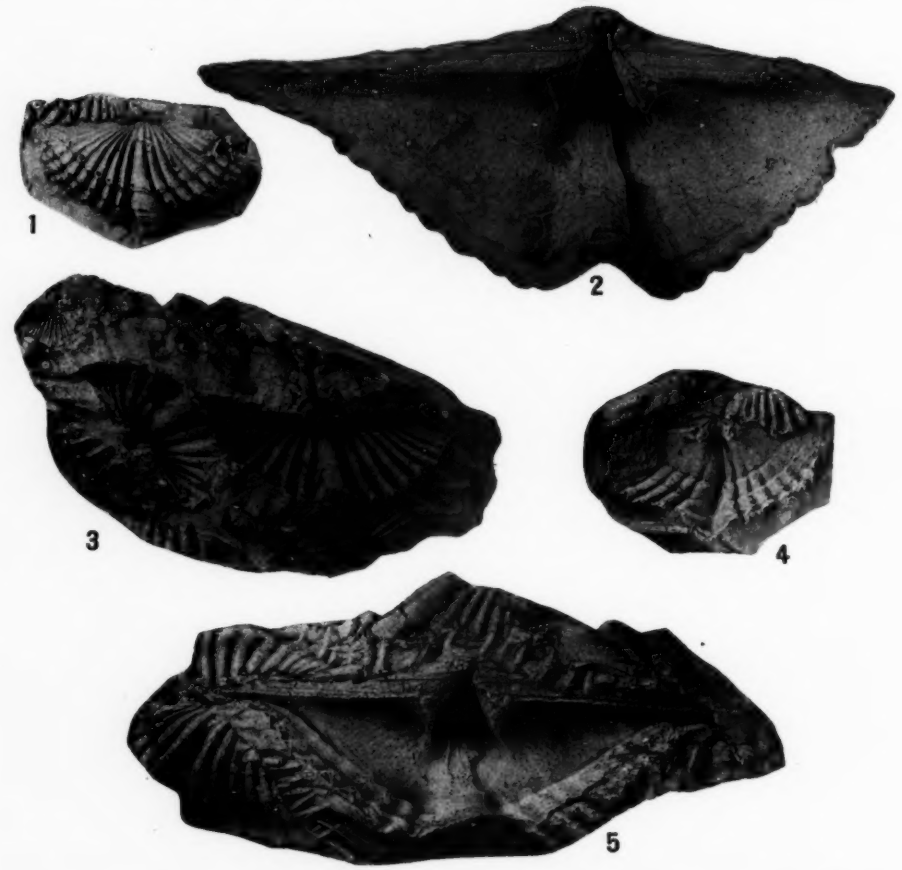
5—*Leptostrophia magnifica* (Hall). Dorsal interior (USNM 28063), 6 miles W. of Cayuga, Ontario, Canada. Upper Oriskany. (p. 438)

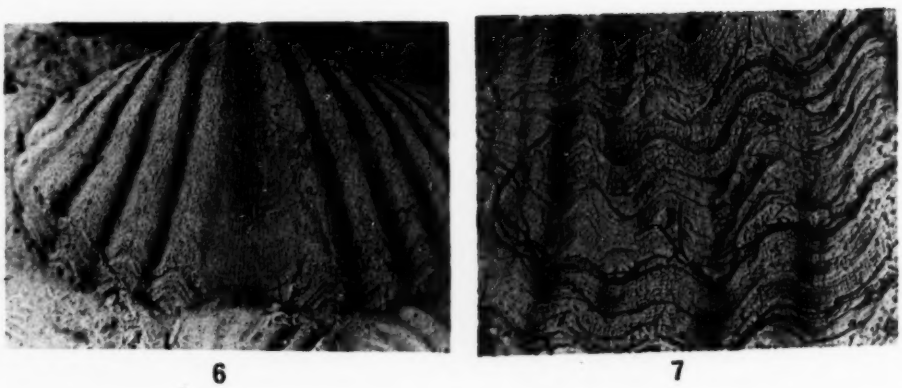
6—*Leptostrophia blainvilli* (Billings). Dorsal interior (USNM 112091), Gaspé, Quebec. (p. 439)

7—"*Stropheodonta magnifica*" Hall. Rubber replica of plaster cast of specimen figured in Hall, 1859, pl. 94, fig. 2d. (USNM 5082b) = "*Leptostrophia*" *magniventra* (Hall). (p. 438)



Allan, New Zealand Devonian Brachiopods





Allan, New Zealand Devonian Brachiopods

STROPHEODONTA HUTTONI
Allan, n. sp.
Plate 61, figure 3

1935. *Leptocoelia flabellites* ALLAN, New Zealand Geol. Surv. Pal. Bull., no. 14, p. 21, pl. 2, fig. 6—not of Conrad, 1841.

Remarks.—The record of *Leptocoelia flabellites* (Conrad) from Reefton was based on a single imperfect internal mold of the dorsal valve. Restudy shows that the determination was very wide of the mark and is, in fact, indefensible. To make matters worse *Leptocoelia flabellites* (Conrad) was one of the few significant "austral," i. e. South African-South American, elements in the Reefton fauna; and, although this "austral" element was minimised by the writer (Allan, 1935, pp. 34–35, and 1942, p. 145), A. L. Du Toit (1937, pp. 62–63 and 65) claimed this record as evidence in support of a Lower Devonian geosyncline, the Samfrau, by which interchange between New Zealand and the "austral" Devonian area of South Africa and South America might have taken place. The correction of a faulty determination thus clarifies the position as far as the "austral" element at Reefton is concerned.

I have to thank Dr. G. A. Cooper for suggesting that the Reefton fossil is a strophеodontid.

It would, perhaps, have been wise to await better specimens before naming this species, but because it has been given a fictitious palaeogeographic significance, I have decided to give it a name.

Description.—(based on the unique holotype, in the N. Z. Geological Survey Collection, an internal mold of the dorsal valve.) Dorsal valve flat, then strongly geniculate near the anterior border, with a wide hinge line (which is abraded so that hinge crenulations, if present, cannot be seen) and semicircular outline. The hinge line equals the greatest width of the shell. Cardinalia consisting of a broad subumbonal callus from which a pronged sessile cardinal process arises (the prongs are broken in the holotype but their stumps seem to be present). Crural plates absent. The musculature rests on a callus platform and consists of reniform posterior adductors, ill-defined in shape, which lap round but do not enclose, small, elongate tear-shaped anterior adductors lying more or less parallel to the median septum. The shaft of the cardinal process continues forward as a rounded septum which is restricted and grooved between the anterior adductors, then expands to form a distinct ridge which extends beyond the callus platform.

The ornament consists of ten or eleven broadly rounded ribs which show on the inner surface of the valve.

Dimensions: length of dorsal valve, 15 mm.; breadth, 20 mm.

Remarks.—The Reefton fossil is referred to *Stropheodonta* in a wide sense; it is probably a distinct generic stock. The interior of the dorsal valve, as far as the details can be observed on imperfect material, is of the same general type as in the genotype, *Strophomena demissa* Conrad (Acad. Nat. Sci. Jour., vol. 8, pt. 2, 1842, p. 258, pl. 14, fig. 14 and Cooper, in Shimer and Shrock, 1944, pl. 131, figs. 12–14).

Stropheodonta huttoni Allan, n. sp. appears to be generically related to *Orthis murchisoni* d'Archiac and Verneuil (Geol. Soc. London Trans., ser. 2, vol. 6, pt. 2, 1842, p. 371, pl. 36, fig. 2; and see *Stropheodonta murchisoni* (A. and V.), Drevermann, Palaeontographica, Bd. 49, 1902, pp. 110–111, taf. 14, figs. 4–8, and Maillieux, 1931, pp. 15–19, pl. 1, figs. 3–8). *Stropheodonta murchisoni* (A. and V.) is a characteristic fossil of the Middle Siegenian (Rauhflaser Schichten) of Germany and Belgium, and extends into the

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EXPLANATION OF PLATE 62

See remarks in explanation of plate 61. All from the Reefton beds at Lankey Creek, Reefton, New Zealand.

FIGS. *1, 3, 4, 6—Mauispirifer hectori* Allan, n. sp. *1*—Paratype, dorsal exterior, the same specimen as fig. 4, *AC.* 3—Holotype, ventral interior (right hand specimen), NZGS. *4*—Paratype, dorsal interior, the reverse of fig. *1*, AC. *6*—Paratype, ventral exterior, ×3, NZGS. (p. 445)

2, 5, 7—Spirifer coxi Allan, n. sp. *2*—Holotype, ventral interior (original of Allan, 1935, pl. 2, fig. 1), NZGS. *5*—Paratype, ventral interior, AC. *7*—External ornament, ×4. AC. (p. 447)

Unterkoblenz-schichten (Lower Emsian) of the Eifel and Belgium.

The species appear to be closely related, sharing the type of ribbing, the geniculation, and the same type of dorsal interior.

The U. S. National Museum has a plaster cast of *S. murchisoni* (A. and V.) from the Lower Emsian, Pesche graywacke, of Grupont, Belgium (Cat. No. 87248) which although imperfect shows a dorsal interior similar to the New Zealand fossil.

Family CAMAROTOECHIIDAE Schuchert, 1929

Genus TANERHYNCHIA Allan, n. gen.

Genotype, *Eatonia parki* Allan, 1935. Lower Devonian, New Zealand.

Description.—Coarsely multicostate Camarotoechiidae with the ventral muscle field restricted to the posterior half of the valve; teeth without dental plates but buttressed by delthyrial ridges; hinge sockets corrugated, bounded by linear socket-ridges; crura short and bluntly pointed; cardinal process with erect shaft and flat, rugose myophore filling the hinge trough; anterior commissure uniplicate.

TANERHYNCHIA PARKI (Allan, 1935)
Plate 63, figures 4, 5

1935. *Eatonia parki* ALLAN, New Zealand Geol. Surv. Pal. Bull., no. 14, p. 22, pl. 2, fig. 11.

Description.—Ventral interior—Shell transversely oval, depressed convex. Anterior commissure strongly uniplicate, ornament coarsely multicostate (as shown by the crenulated anterior margin) with four costae on the floor of the ventral sulcus, and about eight to ten on each flank. Muscle field impressed, bounded laterally by low carinae, restricted to the posterior half of the valve. Diductor scars large, tear-shaped, completely surrounding small, oval, posteromedian adductor scars which are clearly defined by carinae. There is a faint posterior median ridge which terminates within the adductor scars. Teeth strong, without vertical dental supports, but apparently buttressed on the inner sides by plates which do not extend ventrally to the floor of the valve, but are parallel to the edges of the delthyrium. These plates may be homologous with the structures termed "delthyrial ridges" by Fredericks (1927, p. 2, taf. 1, fig. 3) and observed by him in *Brachythyris*, *Anelasma* and *Schuchertella*.

Dorsal interior—Shell strongly convex, with three costae on the pronounced fold. Median septum short, stout, expanding posteriorly, lying almost ventrodorsally, under the cardinalia and united therewith. Muscle field obscure. Hinge sockets large, wide, with their floors transversely corrugated, bounded by linear socket ridges. Crura short and bluntly pointed. Hinge trough filled by what is interpreted as the rugose myophore of a large cardinal process, the shaft of which is short and erect. The myophore does not project above the socket ridges.

Holotype.—An internal mold of the ventral valve (Allan, 1935, pl. 2, fig. 11), in the New Zealand Geological Survey Collection. Paratype, a dorsal interior (pl. 63, fig. 5 herein) from the *Beachia* band, Lankey Creek, in the Allan Collection.

Remarks.—This species was described by the writer as an *Eatonia*, type *Atrypa medialis* Vanuxem (for figures see Cooper, in Shimer and Shrock, 1944, pl. 118, figs. 41–43). The resemblance is superficial; in *Eatonia* the ventral muscle field is large and flabellate, and in the dorsal valve the cardinal process is large with the myophore long and divided into two branches extending into the ventral valve (Cooper, ibid., p. 311).

The New Zealand fossil may be compared with species referred to the genus *Uncinulus* Boyle (Explic. de la Carte Géol. France, IV, Atlas, 1878, pl. ii, figs. 17–20—type *Hemithyris subwilsoni* d'Orbigny, 1850), for example, *Uncinulus antiquus* (Schnur) as illustrated by Drevermann (1902, taf. 12, fig. 15) from Oberstadtfeld in the Eifel. But the genotype of *Uncinulus* is a different type of shell with fine multicostate ornament, an enormous ventral muscle field, and according to Cooper (ibid., 1944, p. 313), a small dorsal cruralium.

Family SPIRIFERIDAE King, 1846

Spiriferids are among the commonest fossils in the Lower Devonian mudstones at Reefton. In 1935 the writer referred two species to the gens of *Spirifer hercyniae* Giebel (Allan, 1935, pp. 15–17)—a term used to cover what was believed, following the earlier work of Scupin (1900, p. 132),

to represent an evolutionary series the stages of which appeared to have stratigraphical value in the Lower Devonian sequence of the Belgian-Rhine province. The gens had its origin in the Devonian, in *Spirifer hystericus* (Schlotheim) from which the following species evolved in the order given, namely, *S. subhystericus* Scupin, *S. primaevus* Steininger, *S. hercyniae* Giebel and *S. paradoxus* (Schlotheim).

Two stages in the European lineage, namely *hystericus* and *hercyniae* were believed to be represented by comparable forms at Reefton.

Allan stated that related species, all of which he included in the genus *Acrospirifer* Helmbrecht and Wedekind (type: *Spirifer primaevus* Steininger), were cosmopolitan in distribution occurring in Europe, northeastern America, South America, Falkland Islands, South Africa and New Zealand.

These conclusions need reinvestigation for two reasons. First, Allan unfortunately overlooked the fact that *S. hystericus* (Schlotheim) is the type of *Hysterolites* Schlotheim, 1820. If the assumed lineage, that is the gens of *S. hercyniae*, is really a closely knit genetic stock, and if the genus is to represent an evolving lineage rather than a cross section of it, then *Acrospirifer* should fall as a synonym of the name *Hysterolites*. If, on the other hand, *S. hystericus* is not closely related to *S. primaevus*, both names can stand.

The second reason for restudy results from Caster's work on the Devonian fauna of Colombia (1939). He re-examined the spiriferids of the "austral" province of South America and South Africa—previously monographed by J. M. Clarke (1913, pp. 220–264)—and concluded that species referred to *Acrospirifer* by the writer (1935, p. 16) belonged to a homeomorphic genus which he named *Australospirifer* (type: *Spirifer kayserianus* Clarke, 1913). According to Caster true *Acrospirifer* occurs with *Australospirifer* in the Colombian fauna but none of the "austral" spiriferids described by Morris and Sharpe, Reed, Kayser, Clarke and others, belongs to *Acrospirifer*.

Acrospirifer as Caster has incorrectly interpreted it on study of the North American *Spirifer raricostus* group (including *S. cyclopterus* Hall, *S. murchisoni* Castelnau and *S. gaspensis* Billings) is characterized by wholly fimbriated shells, and thus falls into the "*Fimbriati unicispinei*" of Hall and Clarke's classification (1893, pp. 17–21). On the other hand, the "austral" *Spirifers* referred to *Australospirifer* have an unique type of external ornament which Clarke 1913, p. 229) termed radiate-fimbriate. In fact the "austral" species possess a combination of three styles of ornament. An early fimbriate stage is followed by radiate ornament which carries imbricating lamellae. Clarke held that this type of ornamentation, so highly distinctive of these "austral" species, was unknown in the boreal realm. He wrote (1913, p. 264):

> All these facts indicate a common initial stock for the austral Spirifers which is unlike in sculpture any boreal stock, and the resultant mature or specific expressions seem to be the outcome of intensive and retrograde development under conditions of geographic isolation.

Although Clarke referred his species to the Radiati Caster (1939, pp. 161–162) suggested that they might well be primitive Osteolati, and the ancestral stock from which the Middle Devonian boreal Osteolati were derived. He wrote "it still appears as though these primitive *Osteolati* [i.e. *Australospirifer*] developed a series of homeomorphs of the *Fimbriata unispinei* pauciplicates with which, in Colombia at any rate, they intermingled . . . (1939, p. 162).

In regard to the relationship between *Hysterolites* and *Acrospirifer*, studies of the European material by Maillieux (1931, pp. 34–53 and 1941B, pp. 45–53), have clarified the problem. In 1931 he recognized both as subgenera of *Spirifer;* in 1941 he placed *Acrospirifer* as a subgenus of *Hysterolites*. His diagnoses are as follows:

Hysterolites (1941B, p. 45)

> Coquilles ailées, ornées, sur les côtés latéraux, de plis rayonnants plus ou moins nombreux, dont le sinus et le bourrelet sont totalement dépourvus. Champ musculaire ventral limité des deux côtés latéraux, par les lamelles plus ou moins minces des supports dentaires, et non profondément excavé dans le test.

Acrospirifer (1941 B p. 51)

> *Hysterolites* dont le test, au voisinage de la région cardinale, est fortement épaissi. Les supports dentaires, atrophiés, se distinguent mal du test épaissi. Le champ musculaire ventral et profondement excavé. Le sous genre comprend des

formes ailées, dont le bord cardinal coïncide avec la plus grande largeur de la coquille.

It will be noted that Maillieux does not include the fine ornamentation in his diagnoses, and that the criteria given are not based on morphological differences. Such differences as there are could all be due to thickening of the shell, and to increase in lateral extension of the cardinal margin in *Acrospirifer* as Maillieux understands that genus.

SURFACE ORNAMENT IN THE SPIRIFERIDAE

It is worthwhile to digress in order to discuss briefly the significance of ornamentation in the Spiriferidae. Hall and Clarke's arrangement of the North American Paleozoic Spirifers (1893, pp. 10–40) was based largely on external characters, in spite of their statement that actual generic differences "are confined to the interior and the intimate structure of the valves; external variations, as far as now known, when unaccompanied by internal changes, must be regarded as of altogether subordinate value" 1893, p. (11). It is now clear that Hall and Clarke's classification is not sufficiently detailed to express fully or adequately the bewildering combinations of ornament which are found in the Spiriferidae.

Clarke was later to express a different point of view. In his treatment of the spirifers of South America in discussing the work of his predecessors in this field (1913, pp. 222–223) he wrote

> With a few noteworthy exceptions no attention has been paid to the most dependable of structural features especially in the group of plicated Eodevonian species, the external sculpture, which certainly could have been determined if the all important external mold had not been so often ignored in favor of the variable, untrustworthy and historically overestimated internal cast.

In his classification of the Spiriferidae Fredericks (1926) employed internal characters for the recognition of subfamilies which in turn were subdivided into genera on the basis of external ornament. In a valuable essay George (1933, pp. 428–429) has criticized Fredericks' scheme for its artificiality and its lack of an evolutionary and phylogenetic basis. George argued that some of Fredericks' genera may contain homeomorphic end products of genetically unrelated forms. George may be correct, but it seems clear that external ornament is one of the best guides to genetic lines, and the ideal is to link such external characters with internal features.

C. L. Fenton has shown, in the *Spirifers* of the Devonian Hackberry formation of Iowa, that "Within a given evolutionary line the dominant trend in ornament progresses *pari passu* with the corresponding trend in gross characters." (1931, p. 64). Under the latter term he included the nature of fold and sinus, plications and shell-outline One may expect, therefore, that a similar relationship should exist between surface ornament and internal morphology.

This relationship is clear in some new genera of the Spiriferidae recently described by G. A. Cooper (1942, pp. 231–232). For example, in *Fimbrispirifer* and *Costispirifer*, highly distinctive external ornament patterns are correlated with equally distinctive internal structures. Study of the material in the U. S. National Museum shows clearly that these genera include groups of related species which are successive in time, in other words, the genera have a phylogenetic significance as well as being morphologically distinct.

The conclusion to be reached is that while external ornament is not in itself a sufficient guide to genetic stocks, when linked with other biocharacters, external and internal, it is an invaluable criterion of affinities.

The systematics of the Spiriferidae is in a chaotic state, as a comparison of recent classifications by Schuchert and Le Vene (1929), Fredericks (1926), Paeckelmann (1931) and Semichatova (1934) will demonstrate, and monographic treatment is urgently needed. The task will be as difficult as it will be interesting, and it is certain that it will involve study of well-preserved exteriors and interiors of topotypic material from all parts of the world. It is, therefore, a task which will demand coöperation on a world scale; at the present time no single collection is rich enough to include more than a small part of the material it will be necessary to assemble and study. Until this monographic treatment is carried out it should be a paleontological crime to describe new genera of the Spiriferidae except in cases where the

material allows of a description of both external and internal morphology.

Genus MAUISPIRIFER Allan, n. gen.

Type: *Mauispirifer hectori* n. sp. Lower Devonian, New Zealand.

Description.—Small, transverse, biconvex Spiriferidae with non-plicated fold and sulcus and pauciplicate lateral slopes. Anterior commissure uniplicate. Ventral valve larger and slightly more convex than the dorsal valve. Hinge line straight, equal to the greatest width of the shell. Surface ornament of fine radial threads which wax and wane in thickness, and which may become pseudo-fimbriate when crossed by concentric growth lamellae near the anterior margins. Ventral interior with well-developed short, thin dental plates and prominent umbonal cavities. Cardinalia with a deep hinge trough and a low, sessile cardinal process with its upper surface irregularly striated. Dorsal median septum long, low and thin.

Remarks.—In shape, and in other gross external characters, such as pauciplication of the lateral slopes, and non-plicated fold and sulcus, the genotype is similar to Helderbergian and Siegenian spiriferoids which have been referred to *Hysterolites* Schlotheim. The ventral internal molds of the Reefton fossil are very similar to those of various Lower Devonian species of *Hysterolites* but this similarity is deceptive. The fine ornamentation of the genotype is radiate, not fimbriate, and the resemblances between it and the Lower Devonian species with which it has been compared are due to homeomorphy. *Mauispirifer* is a radiate homeomorph of the fimbriate *Hysterolites*.

The surface ornamentation of *Mauispirifer*, while quite unlike the fimbriate type found in *S. cyclopterus* Hall, *S. murchisoni* Castelnau and *S. pellico* Verneuil and Archiac (=*hercyniae* Giebel)—all of which have been referred incorrectly to *Acrospirifer*—is, nevertheless, reminiscent of that of *S. primaevus* Steininger, the genotype of *Acrospirifer*.

In *A. primaevus* the radial striae are narrower than the interspaces and somewhat undulating, whereas in *M. hectori* n. sp. they are about the same width as the interspaces and quite regular. This is not in itself a generic difference but distinguishing characters are found in the interiors of both valves. In the ventral valve of *A. primaevus* (see Maillieux, 1931, pl. 2, fig. 1) the muscle field is very large and deeply impressed on the floor of the valve; while in the dorsal interior (see Maillieux, 1931, pl. 2, fig. 2) there is a well-developed median septum, and a distinct cardinal process. *Mauispirifer* and *Acrospirifer* agree in both having non-plicated fold and sulcus, and in possessing pauciplicate lateral slopes. However the two genera, as interpreted by their genotypes, have a different look, which is difficult to define but shows itself in general shape and disposition of the plicae. *Mauispirifer* is transverse; the anterior margin is semicircular in outline and the ends of the plicae make regular, rounded indentations in the semicircular profile; *Acrospirifer primaevus* is longer in proportion to the breadth, and the anterior margin has an irregular profile owing to the projection of the angular ends of the plicae.

The differences seem to be greater than the resemblances; consequently the Reefton fossil is made the type of a new genus which is regarded as a homeomorph of *Acrospirifer*.

MAUISPIRIFER HECTORI Allan, n. sp.
Plate 62, figures 1, 3, 4, 6

1935. *Acrospirifer* cf. *hystericus* (Schlotheim), ALLAN, New Zealand Geol. Surv. Pal. Bull., no. 14, p. 19, pl. 2, figs. 4–5.
1942. *Hysterolites* cf. *hystericus* Schlotheim, ALLAN, Royal Soc. New Zealand Trans., vol. 72 (2), p. 147.

Description.—Ventral exterior—Shell small, transverse, with the cardinal margin equal to the greatest breadth; ratio of length to breadth, from .35 to .5:1. Hinge line straight. Hinge extremities variable, from blunt acute to slightly produced. Lateral margins arcuate. Valve strongly convex, umbo prominent, incurved; cardinal area moderately arched, the breadth of the shell, and fairly long; delthyrium large, acute. Lateral slopes with six to nine plicae which are strong, coarse and subangular; furrows medium deep and subangular. Sulcus non-plicate, subacute, wide. Surface ornament, over the whole shell, of very fine, radial threads which wax and wane in thickness;

concentric growth-lines inconspicuous, confined to the anterior margin.

Ventral interior—Dental plates situated under the second furrow from the sulcus, slightly diverging, short and thin. Teeth small, simple. Umbonal cavities wide, deep and prominent. Muscle scars not impressed; median adductors narrow, elongate, situated on the sulcus. Median septum incipiently developed, thread-like (best seen in immature specimens).

Dorsal exterior—Shape as for the ventral valve but the convexity of the valve is less. Median fold dominant, produced anteriorly, abrupt, rounded. Ornament as on the ventral valve except that concentric growth lamellae are more prominent near the anterior margin, with the result that the radii are broken and a pseudo-fimbriate ornament is developed.

Dorsal interior—Dental sockets narrow but distinct, bounded interiorly by thin socket ridges which are produced anteriorly into rather prominent crural bases. Hinge trough broad and deep. Cardinal process consisting of a large, oval, sessile plate hardly raised above the surface of the hinge trough, and with the upper surface irregularly striated in a posterior-anterior direction. Muscle scars not impressed. Median septum low and thin, extending nearly two-thirds the length of the valve. Brachidia not preserved.

Holotype.—An internal mold of the ventral valve, in the New Zealand Geological Survey Collection (the original of pl. 2, fig. 5 in Allan, 1935). Two paratypes, one of which is an internal mold of the ventral valve (pl. 62, fig. 3, left hand specimen), and the other an impression of the ventral exterior (pl. 61, fig. 6 herein) are on the same slab as the holotype.

Paratypes, ventral molds, are in the U. S. National Museum (Cat. No. 112108) and in the writer's collection which also contains the original of pl. 62, figs. 1 and 4 herein, an internal mold of the dorsal valve, and an impression of the dorsal exterior of the same specimen.

Remarks.—This species was compared with the European Siegenian genotype of *Hysterolites* Schlotheim, *H. hystericus* Schlotheim, and with the North American *Spirifer cyclopterus* Hall which, according to Williams and Breger "is hardly distinguishable from many forms of *S. hystericus* Schlotheim . . . " (1916, p. 94). Restudy of the Reefton material, and comparison of it with typical *S. cyclopterus* Hall in the U. S. National Museum, shows that the New Zealand fossil must be distinguished from the American species because of differences of surface ornament. In *S. cyclopterus* Hall, and in its closely related derivative *S. murchisoni* Castelnau, the ornamentation consists of closely spaced concentric fringes of fine spines. They are typically fimbriate, and such radial ornament as exists is quite subordinate and interrupted (see Clarke, 1900, pl. 6, figs. 29–30 for illustrations of this ornament in *Spirifer murchisoni* Castelnau).

In the Reefton fossil, on the other hand, the ornament consists of very fine radial striae which wax and wane. Concentric ornament is not conspicuous.

If the type of surface ornamentation has any generic significance in the Spiriferidae the Reefton species cannot be grouped with *S. cyclopterus* and its allies in North America.

A comparison of the Reefton fossil with *Hysterolites hystericus* Schlotheim (for a good description of which see Maillieux, 1931, pp. 36–41, pl. 1, figs. 14–15) shows that the supposed relationship cannot be substantiated. Maillieux has given the following description of the ornamentation "Côtes et sillons sont recouverts de fines lamelles d'accroissement concentriques, imbriquées, plus ou moins rapprochées" (1931, p. 41).

The fine radial ornamentation which distinguishes the Reefton fossil from *S. cyclopterus* Hall, also separates it from the genotype of *Hysterolites* which, therefore, must be dismissed from the Reefton fauna.

On the other hand the genus has been described from the Baton River beds by Shirley who recorded "*Spirifer* (*Hysterolithes*) cf. *subspeciosus* (de Verneuil)" (1938, p. 480, pl. 44, fig. 3) and stated that the ornament is of the same type as that of *S. carinatus* Schnur which is a true *Hysterolites*.

Dr. Ida Brown, University of Sydney, who has read my manuscript, has suggested that *Mauispirifer hectori* n. sp. may be related to *Spirifer yassensis* de Koninck and *S. latisinuatus* de Koninck (see Mem. Geol. Surv. N. S. Wales, Palaeont., No. 8, 1898, pp. 83–84, pl. III, figs. 6 and 7) described

from black limestones in the Yass-Murrumbidgee district of New South Wales. These limestones, according to Dr. Brown, underlie Middle Devonian limestones with the Reefton corals *Favosites murrumbidgeensis* Allan and *Eridophyllum bartrumi* Allan. Dr. Brown had presented specimens of *Spirifer yassensis* de Koninck to the U. S. National Museum, and examination of these shows that the fine ornamentation is finely radiate but that the radii tend to be less regular than those of *Mauispirifer*, being broken, on some specimens, into greatly elongated granules. This possible relationship will be investigated further when more material from Reefton becomes available.

SPIRIFER COXI Allan, n. sp.
Plate 62, figures 2, 5, 7

1935. *Acrospirifer* cf. *hercyniae* (Giebel), ALLAN, New Zealand Geol. Surv. Pal. Bull., no. 14, pp. 18-19, pl. 2, fig. 1.

Description.—Ventral interior (from the holotype, an internal mold)—Ventral valve large, convex, very wide, cardinal extremities alate, with a prominent sulcus, and coarse plicae on the lateral slopes. The width is nearly three times the length. Hinge line straight, equal to the width of the shell. Cardinal area very prominent, almost flat, transversely striated. Delthyrium large, acute. Posterior part of valve greatly thickened. Teeth large, blunt, supported by massive dental plates which are slightly divergent, short, and continued anteriorly as low carinae which expand laterally and then curve towards the median plane, bounding the muscle field which is impressed.

The inner faces of the delthyrial cavity immediately ventral to the edges of the delthyrium slope inward and meet the outwardly sloping dental plates in an obtuse angle. These inwardly sloping plates, on the dorsal edges of which the teeth are situated, are apparently formed as the teeth grow in an anterior direction, and each represents a tooth-track. In immature specimens the umbonal cavities are distinct and moderately deep. In adult specimens however the cavities are filled with secondary deposits. The inner surface of the shell, immediately outside the dental plates, is pustulose. Delthyrial cavity deep.

The muscle field is strongly impressed, elongate-ovate in shape, widening anteriorly. Diductor muscle scar large, elongate, surrounding small, elongate adductor scars situated on the prominent ridge (the convex inner surface of the ventral sulcus) which divides the muscle field. The diductor scars are striated, with the striae irregularly transverse over the posterior half of the field, and more or less longitudinal over the anterior half. There is a very short, thin, median septum which does not extend as far anteriorly as the adductor scars.

The surface plication is coarse enough to show traces of plicae on the inner surface of the valve. The sulcus is non-plicate, and each lateral slope has about 8 to 10 plicae. The anterior commissure is strongly uniplicate.

Dorsal interior—Unknown.

External ornament—The plicae and furrows are broadly rounded in cross section. The fine ornament is radiate—fimbriate in type. The radial striae are very fine, and broken into small, elongated beads by the concentric growth lamellae which are closely spaced near the anterior margin. Near the cardinal margin the striae are oblique, converging posteriorly on the furrows, and anteriorly on the plicae. The oblique type of ornament gives place, nearer the anterior margin, to a radiate-fimbriate pattern.

Holotype.—An internal mold of the ventral valve, the original of pl. 2, fig. 1 in Allan, 1935, in the N. Z. Geological Survey Collection; paratypes, also ventral internal molds, in the U. S. National Museum (Cat. No. 112110) and in the writer's collection.

The originals of pl. 2, figs. 2 and 3 of Allan, 1935, belong to this species and illustrate changes in shape resulting from deformation of some bands in the Reefton mudstones.

Remarks.—This common Reefton fossil was previously referred to *Acrospirifer* Helmbrecht and Wedekind (type: *Spirifer primaevus* Steininger, 1853—for a description of which see Maillieux, 1931, pp. 44–47, pl. 2, figs. 1–2; and 1936, pp. 98–99, pl. 1, fig. 5). Maillieux has shown that in the genotype the ornamentation is radiate. He wrote (1936, p. 98):

Nous n'aurions rien à ajouter à ce que vous avons écrit en 1910 et en 1931 au sujet de cette espèce si vous n'avions eu la bonne fortune de recue ller

quelques belles empreintes de jeunes individus montrant nettement les caractères d'une ornementation que l'âge, fréquemment, fait disparaître par l'usure. Ces exemplaires montrent que les fortes côtes rayonnantes qui recouvrent les valves sont elles-mêmes ornées de nombreuses et très fines stries rayonnantes, qui ne parnaissent pas interrompues par les stries d'accroissement de la coquille.

In the U. S. National Museum there is a plaster cast (Cat. No. 87269) of *Acrospirifer primaevus* (Steininger) sent by Maillieux, from Longlier (assise de St. Michel, base des Herdorfer-schichten). This shows the ornamentation just as Maillieux has described it.

Consequently, the Reefton fossil, with its very distinctive ornamentation, cannot be placed in *Acrospirifer*, nor is it congeneric with *Mauispirifer* the genotype of which was first referred to *Acrospirifer* by the writer.

Spirifer coxi n. sp. was compared with *Spirifer hercyniae* Giebel, but once again a too great reliance on similarities in the internal characters of the ventral valve has proved a source of error. Maillieux (1931, pp. 48–53 and 1936, p. 99, pl. 1, fig. 4) has restudied Giebel's species and referred it to the earlier *Spirifer pellico* de Verneuil and d'Archiac, (1845 Soc. Géol. de France Bull., ser. 2, vol. 2, p. 472, pl. 15, figs. 1a–c.) *S. pellico* V. and A. is placed by Maillieux in *Acrospirifer*. This is curious for a plaster cast of this species sent by Maillieux to the U. S. National Museum (Cat. No. 87266) from Martelange (Assise d'Anor-Rauhflaser Schichten) is fimbriate, quite unlike the radiate genotype of *Acrospirifer*.

It is clear that the oblique radial ornamentation, so beautifully developed on *Spirifer coxi* n. sp., separates it at once from these European species which belong to homeomorphic groups.

Unfortunately the dorsal valve of *Spirifer coxi*, n. sp. is not represented in the Reefton material now available for study. Furthermore the ornamentation described above is clearly developed only on a fragmentary specimen. The Reefton fossil almost certainly represents an undescribed generic stock of Lower Devonian spiriferoids but until further collecting allows of study of the dorsal interior, and of the ornamentation on complete ventral and dorsal exteriors I hesitate to propose a new genus for it. I, therefore, refer it to *Spirifer* in a broad sense, noting, however, that it is not closely related to the Carboniferous genotype, *S. striatus* (Martin, 1809).

Acrospirifer must be dismissed from the Reefton fauna but may be retained temporarily in the Devonian of New Zealand on the basis of Shirley's record (1938, pp. 480–481, pl. xliv, figs. 4–5) of *Acrospirifer arduennensis* (Schur) from the Baton River beds. The Baton River species shows ornament "of very fine concentric lamellae which are crossed by fine radial lines." This agrees with that of *A. pellico* (Verneuil and Archaiac) but not with that of the genotype of *Acrospirifer*.

In his latest account of the Belgian Devonian Spiriferidae Maillieux (1941A, p. 3) places both *pellico* (V. and A.) and *arduennensis* (Schnur) in *Acrospirifer* which he treats as a subgenus of *Hysterolites* Schlotheim. Maillieux obviously places little reliance on surface ornamentation as a criterion of generic stocks. The writer suggests that the European Lower Devonian Spiriferidae merit restudy with the object of attempting to find generic lines in which type of surface ornament is correlated with internal characters. It would seem that the

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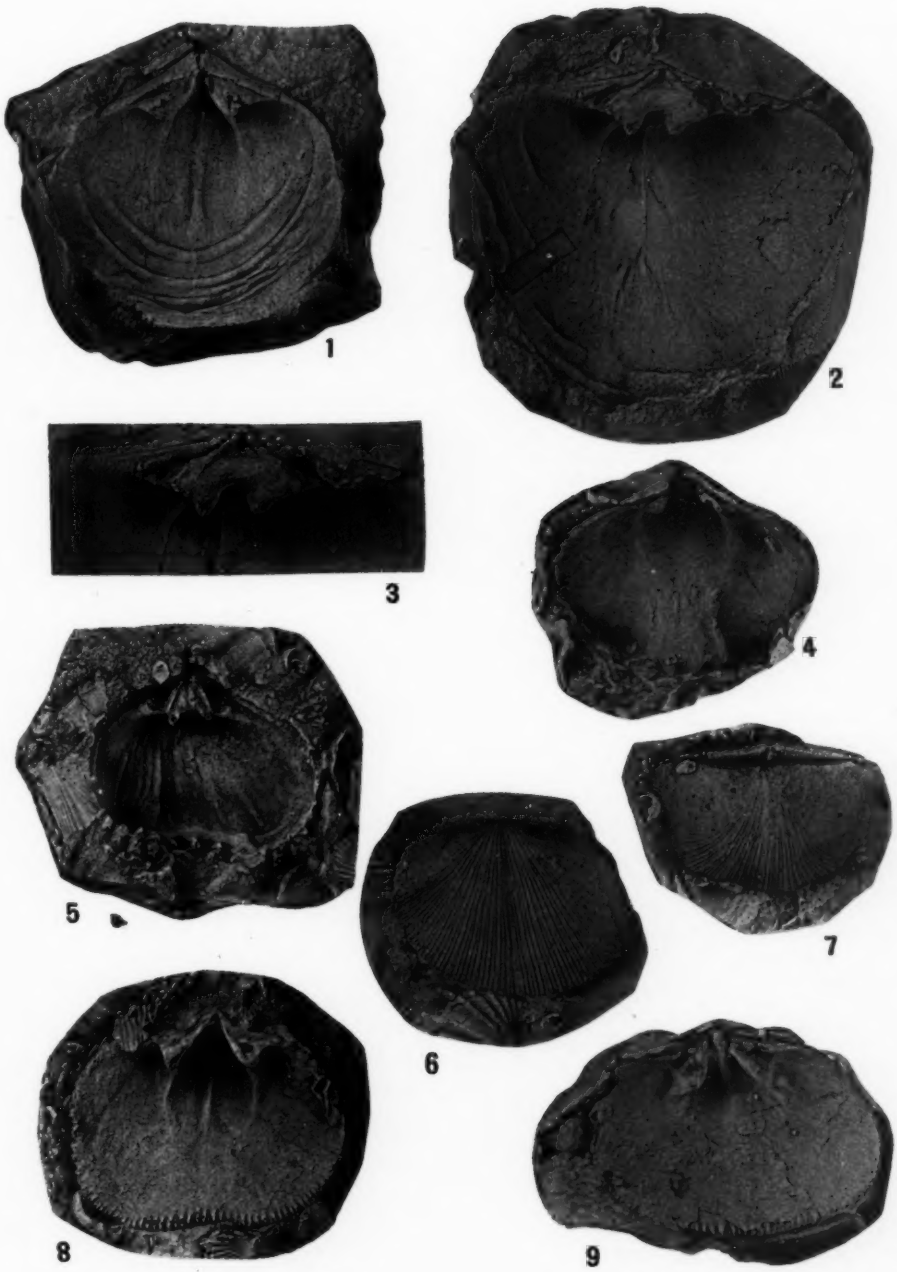
EXPLANATION OF PLATE 63

See remarks in explanation of plate 61. All specimens are from the Reefton beds, Reefton, New Zealand.

FIGS. *1–3—Beachia neozelanica* (Allan). *1*—Holotype, ventral interior (original of Allan, 1935, pl. 2, fig. 9), NZGS. *2*—Paratype, dorsal interior (original of Allan, 1935, pl. 2, fig. 10), ×2, NZGS. *3*—Paratype, same specimen as fig. 2; enlargement of cardinalia, ×3. (p. 449)

4, 5—Tanerhynchia parki (Allan). *4*—Holotype, ventral interior (original of Allan, 1935, pl. 2, fig. 11, ×2, NZGS. *5*—Paratype, dorsal interior; *Beachia* band, Lankey Creek, Reefton, ×2, AC. (p. 442)

6–9—Reeftonia marwicki Allan, n. sp. *6*—Paratype, dorsal exterior, Lankey Creek, ×2, AC. *7*—Paratype, posterior ventral view, Lankey Creek, ×2, AC. *8*—Paratype, ventral interior (original of Allan, 1935, pl. 3, fig. 4), Locality 130, Reefton, ×2, NZGS. *9*—Holotype, dorsal interior (original of Allan, 1935, pl. 3, fig. 7), Locality 130, Reefton, ×2, NZGS. (p. 437)



Allan, New Zealand Devonian Brachiopods

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primaevus stock (*Acrospirifer*) is distinct from the *pellico-*(=*hercyniae*) line. The latter, as far as ornamentation is concerned, is possibly derived from, and related to, *Hysterolites*, but this cannot be so for the *primaevus* group with its radiate ornamentation.

It may be noted as a byproduct of this revision that the group of North American Lower Devonian *Spirifers*, including *S. cyclopterus* Hall, *S. murchisoni* Castelnau and *S. gaspensis* Billings, referred to *Acrospirifer* by Caster or by Cooper (1944, pp. 323–324 and pl. 123, figs. 9–11 and 15–16) are all fimbriate. Consequently they cannot be congeneric with the radiate genotype *A. primaevus* (Steininger).

Family CENTRONELLIDAE Hall and Clarke, 1895
Subfamily EURYTHYRINAE Cloud, 1942

Genus BEACHIA Hall and Clarke, 1893

1893. *Beachia* Hall and Clarke, Nat. Hist., New York, pt. 6, Palaeont., vol. 8 (2), p. 260, pl. 77, figs. 1–11.
1942. *Beachia* Cloud, Geol. Soc. America Special Papers, no. 38, pp. 60–61.

Type (by monotypy) *Meganteris suessiana* Hall, 1857, New York State Cab. N. H. Tenth Ann. Rept. p. 100. Oriskany, Maryland.

BEACHIA NEOZELANICA (Allen, 1935)
Plate 63, figures 1–3

1935. *Meganteris neozelanica* Allan, New Zealand Geol. Surv. Pal. Bull., no. 14, pp. 23–24, pl. 2, figs. 9–10; pl. 3, figs. 3, 5.

Description.—Exterior: Beak short, suberect; cardinal margin terebratulid; foramen probably mesothyrid; beak ridges sharp, defining prominent but narrow planareas; deltidial plates conjunct; shell surface smooth.

Ventral interior (from rubber replica of holotype): Hinge teeth heavy and large, buttressed by dental plates, which curve forward and then inward as carinae of rapidly decreasing height, to define the muscle field which is but slightly impressed. Muscle field elongate-oval, rather more than half the length of the valve; adductor impressions small subovate; with a low broad myophragm in the median plane. Widely spaced concentric growth stages are conspicuous on the anterior half of the valve.

Dorsal interior (from rubber replica of paratype): Cardinalia consisting of a broad, flat, sessile cardinal plate, without cardinal process, with a posterior, central pit (? indicating the presence of a dorsal foramen), and resting on discrete crural plates. Cardinal plate overhanging anteriorly, slightly concave in front of the dorsal foramen, and gently rounded parallel to the greatest breadth; bounded laterally by convergent socket ridges. Dental sockets long and shallow. Crura prominent, broadly pointed, and separated by a rounded embayment in the anterior edge of the cardinal plate. Muscle field impressed; posterior adductors elongate, surrounding medially placed and small anterior adductors. The muscle field is divided medially by a myophragm (Cloud 1942, p. 14) which is broad posteriorly, then restricted at the posterior edge of the anterior adductors, and tapers to a point within the latter.

Remarks.—The writer compared the Reefton fossil with *Megalanteris suessi* Drevermann, 1902 (Palaeontographica, 49, p. 102, pl. 13, figs. 1–11, Coblenzian) and with the Oriskany *Megalanteris diobolaris* Clarke (New York State Mus. Mem. 9 (2) 1909, pp. 142–143, pl. 34, figs. 1–5, particularly fig. 5).

Cloud (1942) has shown that species described as *Meganteris* by Hall, Clarke, Holzapfel, and others, including the writer, belong to homeomorphic groups such as *Beachia* and *Prionothyris*. *M. diobolaris* Clarke belongs to *Prionothyris*, and Cloud suggested (1942, p. 67) that the new Zealand species might also belong there.

M. neozelanica Allan is certainly not a *Meganteris*, which as Cloud has pointed out, bears only "a superficial external similarity to *Beachia* and *Prionothyris*" (1942, p. 110). Restudy of rubber replicas of the types of the Reefton species substantiates Cloud's conclusion that it belongs to the family Centronellidae, and to the subfamily Eurythyrinae which includes the genera *Beachia*, *Eurythyris* and *Prionothyris*, all confined to the Lower Devonian, Oriskany and early Onondaga. The only species of the subfamily that are not restricted to North America are the Reefton form, and *Prionothyris australis* (Caster, 1939) from the Devonian of Colombia. *Prionothyris* resembles *Beachia* but

has "a ponderous, erect cardinal process divided at its ventral end into two prominent, concave, serrated diductor attachment pits" (Cloud, 1942, p. 66). In *Meganteris neozelanica* the cardinal process is absent, as in *Beachia*. The Reefton species is here placed in the genus *Beachia* with which it agrees in type of cardinalia and in most other characters. *Beachia neozelanica*, however, does not possess introverted lateral margins.

Apart from the New Zealand species *Beachia* is confined to strata of Oriskany age in North America. Of the described species, *B. neozelanica* comes closest to *Beachia thunii* (Clarke, 1907) (New York State Mus. Bull., 107, pp. 250–251, text-figs.; and Clarke, 1908, p. 168, pl. 26, figs. 8–13, pl. 27, figs. 7–15, as *Megalanteris thunei* nov.—spelling corrected) from the Grand Grève limestone of Quebec.

AGE OF THE REEFTON MUDSTONES

In 1935 the writer, on the basis of comparisons then made with western European species, concluded that the Reefton mudstones contained a fauna of Upper Siegenian age. This restudy seems to show that the comparisons made in 1935 failed to make allowance for the development of homeomorphic groups in New Zealand. The recognition of homeomorphic genera at Reefton means that many of the earlier comparisons have not the significance which the writer placed upon them. To employ them now, would involve the assumption that the homeomorphs were isochronous, and for this there is no justification. The determination of the age of the Reefton fauna must be deduced anew from the affinities now apparent in this revision.

Reeftonia marwicki n. sp. is a monotypic genus but *Orthis eminens* Hall, a Helderberg fossil may prove to belong to it. This genus and species thus is suggestive of a Lower Devonian age. *Leptostrophia reeftonensis* Allan is compared with *L. magnifica* (Hall) and with *L. irene* (Billings), species which are characteristic of the upper part of the Deerpark Stage of the Lower Devonian of North America, i.e. of the Oriskany sandstone and its correlatives. *Maoristrophia* is monotypic and until it is found elsewhere has no direct correlative significance. *Strophheodonta huttoni* n. sp. is related to *Strophheodonta murchisoni* (Archiac and Verneuil) which according to Maillieux (1931, p. 19)

> est une espèce assez cosmopolite: On l'a signalée dans l'Ardenne, en Allemagne, en Angleterre, dans l'Ouest de la France, dans les Pyrénées et en Espagne. Les formations dans lesquelles ont l'a trouvée s'étendent de la base du Siegenian au sommet de l'Emsien.

The species seems to be most characteristic of the Middle Siegenian (Rauhflaserschichten).

Tanerhynchia parki (Allan) is compared with *Uncinulus antiquus* (Schnur) from Oberstadtfeld in the Eifel, where the horizon is Lower Emsian (Untercoblenzschichten). The Reefton species of the Spiriferidae, *Mauispirifer hectori* n. sp. and *"Spirifer" coxi* n. sp., are homeomorphs of typical Lower Devonian boreal species. In this case the homeomorphy is possibly isochronous and indicative of a Lower Devonian age for the Reefton mudstones. *Beachia neozelanica* (Allan) allows of an exact correlation for, apart from the New Zealand species, the genus is confined to strata of Oriskany age in North America.

To sum up: (1) Where the affinities of the Reefton fossils are with North American species, the evidence consistently suggests correlation with the Oriskany sandstone and equivalent strata which form the Deerpark Stage of the Ulsterian Series. According to Cooper [et al.], 1942, Chart no. 4, the Deerpark Stage is equivalent to the Lower Coblenzian of Europe. (2) Where the affinities of the Reefton fossils are with European species the evidence suggests correlation with strata ranging from Middle Siegenian to Lower Emsian (=Lower Coblenzian).

It is a legitimate conclusion to place the fauna of the Reefton mudstones in the middle division of a three-fold classification of Lower Devonian time.

ORIGIN OF THE REEFTON FAUNA

In 1935 the writer concluded that the Lower Devonian strata at Reefton contained a fauna which was closely comparable, in its characteristic fossils, with that of the Upper Siegenian of the Belgian-Rhine province. He was faced with the problem of explaining this unexpected conclusion, and

being unable to find a route, or routes, by which migration from New Zealand to Western Europe (or vice-versa) was feasible, he postulated a cosmopolitan ancestral fauna from which Lower Devonian faunas were derived and believed that these faunas owed their peculiarities to environmental control. For example, the Reefton fauna was believed to be similar to that of the same age in Western Europe because in both area the facies was the same, and to differ from the coeval "austral" Lower Devonian fauna of South Africa and South America, because the facies in that province was different.

After Shirley (1938) had monographed the Baton River fauna of New Zealand, which is also Lower Devonian in age, but of Bohemian facies, and had shown the probability of the existence of a Lower Devonian Tethys Allan (1942) abandoned his 1935 hypothesis, and accepted Shirley's views. After discussing Shirley's work, and considering the results of Caster's study of the Colombian fauna (1939), Allan (1942, p. 145) wrote

> It is thus clear that new records of Lower Devonian faunas of both the Rhenish and the Bohemian facies, together with the demonstration [by Caster] of widespread homeomorphy among Lower Devonian brachiopods leading to the recognition of generic groupings at variance with those suggested by the writer, undermine the earlier reasoning and force the rejection of an untenable hypothesis.
>
> In its place the writer is constrained to accept the view that the origin of the Lower Devonian fauna of the Reefton Beds is to be explained by migration along shore-lines by a route or routes still imperfectly known but of which the most probable and important was the Tethys sea-way.

The result of this restudy suggests that the similarity between the New Zealand fauna and that of Western Europe was to a large extent superficial and that many of the apparent similarities were based on comparison of homeomorphous groups.

If the new genera such as *Reeftonia*, *Mauispirifer*, *Tanerhynchia* and *Maoristrophia* be eliminated because, as yet they are New Zealand groups, not certainly recognized elsewhere, the affinities of the Reefton fauna with that of the Belgian-Rhine area, are greatly reduced. The comparable forms are *Pleurodictyum* cf. *problematicum* Goldfuss, *Chonetes maoria* Allan (compared with *C. sarcinulata* (Schlotheim) and not restudied because of lack of adequately preserved specimens) and *Strophedonta huttoni* n. sp. (compared with *S. murchisoni* (A. and V.)). On the other hand, this restudy shows that *Leptostrophia reeftonensis* Allan is close to American Oriskany species; and that the terebratuloid genus *Beachia*, which is known only from the Oriskany sandstone and its correlatives in North America, is a member of the Reefton fauna.

This last record, which Dr. P. E. Cloud, Jr., confirms, is the most significant of all. The subfamily Eurythyrinae to which *Beachia* belongs, is otherwise restricted to North America and Colombia whence Caster described *Meganteris australis* which Cloud placed in *Prionothyris*.

It is puzzling to account for the presence of this early distinctive terebratuloid in New Zealand, and if dispersal along shorelines in shallow water is the only means by which the distribution of the articulate brachiopods was possible, it appears that a circum-Pacific route was just as probable as one via Tethys. Perhaps both seaways were operative in Lower Devonian times. Our knowledge of Lower Devonian paleogeography and faunas is so incomplete that further speculations on this theme are hardly profitable.

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AN UPPER DEVONIAN BRACHIOPOD FAUNA FROM NORTHWESTERN MONTANA

WILSON M. LAIRD
North Dakota Geological Survey, Grand Forks, North Dakota

ABSTRACT—The fossils described in this report come from the Upper Devonian Jefferson formation of northwestern Montana. The fauna consists largely of corals, brachiopods and stromatoporoids. Only the outstanding brachiopods are described.

STRATIGRAPHY

THE STRATIGRAPHY of the Upper Devonian of northwestern Montana has been described previously by Deiss (1933) and Sloss and Laird (1945 and 1946). The last two authors divide the Upper Devonian of this area into three units which have arbitrarily been designated units Da (subdivided into Da_1 and Da_2), Db and Dc.

Unit Dc is the oldest of the three units and rests disconformably in northwestern Montana on the Cambrian Devils Glen dolomite. The unit consists of a series of red and green dolomitic shales interbedded with brown and reddish brown argillaceous and sandy dolomites. It is nearly barren of fossils save for a few poorly preserved ostracodes and some conodonts. The conodonts have lately been described by Chalmer L. Cooper (1945). He states " . . . the species recognized in the Montana samples show a preponderance of forms of Senecan age from the lower New Albany shale of Indiana and the Rhinestreet shale of New York."

Unit Db is of more immediate interest to this report because it is the source of all the forms herein described. This middle unit is a dominantly brown to brownish-gray dense limestone which is slightly argillaceous toward the base. A few saccharoidal dolomites and some worm burrows filled with yellow argillaceous limestone are present.

This unit has an abundant fauna of corals and brachiopods including the following forms:

Disphyllum catenatum Smith
Disphyllum colemanense (Warren)
Disphyllum sp. cf. *D. arundinaceum* (Billings)
Macgeea sp. cf. *M. solitaria* (Hall and Whitfield)
Phillipsastraea sp. cf. *P. macouni* Smith
Spongophyllum imperfectum Smith
Tabulophyllum rectum Fenton and Fenton
Atrypa missouriensis Miller
Atrypa cf. *montanensis* Kindle
Atrypa spinosa var. *montanensis* Kindle
Camarotoechia saxatilis Hall
Leptostrophia sp. cf. *L. camerata* Fenton and Fenton
Productella sp. cf. *P. walcotti* Fenton and Fenton
Schizophoria iowaensis Hall
Spirifer engelmanni Meek
Spirifer jasperensis Warren
Spirifer raymondi Haynes
Strophonella sp. cf. *S. reversa* Hall
Stropheodonta sp.

Not all the brachiopods are described in the following pages of this report because some of the fossils are too poor for illustration and description. Only the more perfect and characteristic forms are shown.

Overlying unit Db is unit Da, which on the outcrop consists of coarsely saccharoidal dolomite, often cross-bedded. The upper three-fourths of unit Da is extremely brecciated due apparently to slumping caused by the solution of anhydrite which is interbedded with the dolomitic beds of the unit as is shown in the subsurface by deep well cuttings.

A discussion of the stratigraphy is the subject of another report and thus will not be detailed here. The correlation of the units mentioned above with the type area near Three Forks, Montana, is shown in Table I.

The fauna of unit Db appears to be similar to the *Spirifer argentarius* Meek zone within the Devils Gate formation of the Roberts Mountain region in Nevada (C. W. Merriam 1940). In view, however, of the occurrence of a related form, *Spirifer jasperensis* Warren, and other similar related forms in the Jefferson formation of Montana and the Minnewanka limestone of Alberta,

it appears that much, if not all, of Merriam's Devils Gate formation should be placed in the Upper Devonian instead of the uppermost Middle Devonian.

Faunas of similar aspect to those of unit Db are found in the lower part of the Minnewanka limestone of Alberta. "The most abundant *Spirifer* of this fauna is *Spirifer jasperensis* which is believed to be a variety of *Spirifer argentarius* and also linked very closely with *Spirifer engelmanni*, both represented in the Devonian faunas of Nevada and Montana. The fauna occurring in this zone is to be correlated with the Naples-Portage fauna of New York." (Warren 1942). The age assignment of these beds agrees very well with the age determination of the conodonts of the basal Devonian unit Dc made by Cooper and mentioned previously in this report.

TABLE I. CORRELATION WITH DEVONIAN ROCKS NEAR LOGAN, MONTANA

Type section at Logan, Montana	Northwestern Montana	
Three Forks formation	Da	Da_1
Dolomite member of Jefferson formation		Da_2
Limestone member of Jefferson formation	Db	
Basal Devonian unit?	Dc	
Cambrian Dry Creek shale	Cambrian Devils Glen dolomite	

In a recent letter (April 25, 1946) from L. L. Sloss, he notes that the Upper Minnewanka which is called the Pallisser formation by the Canadians is apparently very similar lithologically to the unit Da of northwestern Montana. The lower part of the Minnewanka which is locally called the Fairholme is lithologically identical with unit Db of northwestern Montana. In the Alberta exposures at Banff, no evaporite of any consequence is noted nor is there any vestige of the Three Forks shale. It seems probable that the absence of the Three Forks can be accounted for by facies gradation and that it is represented by part of the Upper Minnewanka.

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SYSTEMATIC PALEONTOLOGY

Genus CAMAROTOECHIA Hall and Clarke

CAMAROTOECHIA SAXATILIS (Hall)

Plate 64, figures 27, 28

1867. *Rhynchonella* (*Stenocisma*) *contracta* var. *saxatilis* HALL, Paleontology. New York, vol. 4, p. 417, pl. 54 A, figs. 44–51.

1924. *Camarotoechia saxatilis* (Hall), FENTON and FENTON, Michigan Univ. Mus. Geology, Contr., vol. 1, p. 123, pl. 25, figs. 13–17

Description.—The shell of this form is small and only slightly wider than long. Two specimens each measure 13 mm. in width and 11 mm. in length. The thickness of one is 7 mm. and the other measures 9 mm. in thickness.

Ventral valve flattened or slightly convex at the umbo. A pointed beak extends slightly beyond the beak of the brachial valve. The lateral slopes are flattened to slightly convex and bear 5 to 7 plications. A deep and fairly well-defined sinus bearing 4 well-marked plications is present. In both specimens the plications in the sinus are more angular than those on the lateral slopes which are subrounded.

The dorsal valve is much more convex than the ventral valve. The beak is sharply incurved, thus making the umbo well rounded. The lateral slopes are abruptly convex. The surface is covered by 15 to 17 angular to subrounded plications. A well marked fold is present bearing 4 plications. In all cases the plications of both valves interlock.

Remarks.—This form corresponds more closely to the description and illustrations of Fenton and Fenton than to those of Hall. It is apparently closely related to *Camarotoechia exima* but the fold on the present form is higher and *Camarotoechia saxatilis* is smaller. Relationship with *Camarotoechia*

congregata is also suggested by Fenton and Fenton. Comparison with Hall's illustrations suggests that *Camarotoechia saxatilis* is somewhat more gibbous and has more plications on the fold and sinus than *Camarotoechia contracta*. Considerable variations with the Fentons' and Hall's could be expected in view of the distance separating the localities.

Occurrence.—These specimens were collected from the Devonian unit Db on Allan Mountain.

Genus SCHIZOPHORIA King
SCHIZOPHORIA IOWAENSIS (Hall)
Plate 64, figures 25, 26

1858. *Orthis iowaensis* HALL, Geol. Iowa, vol. 1, pt. 2, p. 488, pl. 2, fig. 4.
1924. *Schizophoria iowaensis* (Hall), FENTON and FENTON, Michigan Univ. Mus. Geology, Contr., vol. 1, pp. 83–85, pl. 19, figs. 5–11.

Description.—Shell medium size, wider than long. Average length 12.3 mm., running from 10.5 to 15 mm. Average width 17.1 mm., running from 15.5 to 18 mm. The thickness of both valves averages 8.5 mm., running from 5.5 to 10 mm.

The ventral valve is only moderately convex and has a flattened appearance. The surface of the valve slopes gently toward the edge of the shell with a slight flattening toward the hinge line. The beak of the pedicle valve is only slightly elevated and only slightly overhangs the cardinal area which is triangular in shape. A low shallow medial sinus starting about 5 mm. anteriorly from the beak is also usually present.

The dorsal valve is much more gibbous and the surface slopes more abruptly toward the edges of the valve except toward the hinge line where a slight flattening occurs giving small ear-like projections along the hinge line.

The surface of the valves is covered with fine radiating striae which increase toward the anterior margin by implantation. About 12 striae were measured in 4 mm. at midlength of shell. Occasional growth lines are also present but are not prominent. The surface of the shell is also covered with fine punctae.

Remarks.—The specimens at hand most closely resemble the form described by Fenton and Fenton, although the present specimens are on the average smaller than they describe. The interiors of these specimens are not preserved so no comparison with the Fentons' description can be made in this respect. The specimens at hand do not show as deep a medial sinus as illustrated by Hall nor are the present specimens as large as his. However, the resemblance between the forms is strong and the strength of the medial sinus and size appear to vary widely.

Occurrence.—These specimens were collected from the Devonian unit Db on Lone Butte.

Genus ATRYPA Dalman
ATRYPA cf. MONTANENSIS Kindle
Plate 64, figures 1–6

1940. *Atrypa cf. montanensis* Kindle, MERRIAM Geol. Soc. America Spec. Paper 25, pl. 8, figs. 12–17.

Description.—Shell of medium size or less, usually as long as it is wide. The average of eight specimens show that the width is 1 mm. more than the length. The average length of eight specimens is 19.4 mm., ranging from 15.5 to 25 mm. The average width of eight specimens is 20.4 mm., ranging from 16 to 25 mm. The specimens at hand are moderately gibbous showing an average thickness of 10.9 mm., ranging from 9 to 14 mm. in thickness.

The forms at hand most closely resemble those illustrated by Merriam (1940). Unfortunately, he figures them only and gives no description. It is possible that his "cf." in the description means he is comparing the form to *Atrypa spinosa* var. *montanensis* Kindle, (1908). The forms described by Kindle, however, are much smaller than those illustrated by Merriam or those present in the author's collection. Furthermore, Kindle's illustrations do not indicate the presence of a median sinus or fold.

The surfaces of both valves are covered with subrounded costae, both valves having approximately the same number. Of seven specimens the highest number of costae for the ventral valve was 13 and the lowest was 9; for the dorsal valve the highest number was 13 and the lowest was 8. The count of the costae was taken on the umbonal region; toward the anterior part of the shell some of the costae bifurcate, although bifurcation is not too common a phenomenon in the specimens at hand.

Parallel with the costae are the aragonite fibers which comprise the shell substance. This gives an appearance of striations on the costae. The surface of some of the shells has a pitted appearance suggesting spine bases or solution pits.

Growth lines are concentric with the anterior end of the shell. In some of the specimens the nodes formed where the growth lines cross the costae are very distinct.

The shells are moderately gibbous and are convexo-concave. A faint to fairly well defined median sinus is present on the ventral valve with a corresponding fold on the dorsal valve.

Remarks.—It appears that the specimens described herein might justifiably be considered as a new species. There seem to be distinct variations from other described forms such as *A. spinosa* var. *montanensis* Kindle. However, no new name should be given this form until Merriam's original material, which he figured but did not describe, is studied.

Occurrence.—All of the specimens studied came from unit Db of the Devonian on Slategoat Mountain.

ATRYPA SPINOSA var. MONTANENSIS Kindle

Plate 64, figures 7–12

1908. *Atrypa spinosa* var. *montanensis* KINDLE, Bull. Am. Paleontology, vol. 4, no. 20, pp. 28–29, pl. 1, figs. 5–5c.

1924. *? Atrypa owenensis* Webster, FENTON and FENTON, Michigan Univ. Mus. Geology, Contr., vol. 1, p. 141, pl. 26, figs. 9–11.

Description.—Shell small, subcircular to circular, with approximately equally and moderately convex valves. Length about equal to width. Of six well preserved specimens, the average length is 12 mm., running from 7 to 19.5 mm. and the average width is 12.5 mm., running from 7 to 19 mm. The average thickness of the shell is 4.6 mm., running from 2.5 to 7 mm.

The umbos of both valves are low and the shells as a whole have a depressed appearance. The beak of the ventral valve overhangs the cardinal area which is low and practically non-existent.

The surface of the valves is covered by distinct subrounded costae averaging 12 costae for each valve. The costae occasionally bifurcate and all increase in strength toward the edge of the shell. In only one of the specimens is a very slight, indistinct sinus present on the ventral valve with a corresponding fold on the dorsal valve. Concentric growth lines cross the costae giving rise to distinct nodes.

Remarks.—The specimens at hand most closely resemble those illustrated by Kindle, although the size of my specimens appears to average slightly higher than his. He notes, too, the presence of 14 to 20 costae where mine average 12, only one shell showing as many as 15 costae.

The form appears to resemble closely *Atrypa owenensis* Webster as described by Fenton and Fenton. The form they describe has about the same dimensions, except for thickness, as the specimens at hand. Their form is definitely more gibbous and also is

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EXPLANATION OF PLATE 64

All figures enlarged about 1½ times. All specimens are from Devonian unit Db at the localities indicated.

FIGS. *1–6*—*Atrypa* cf. *A. montanensis* Kindle. Slategoat Mountain. *1, 3*, ventral views. *2, 4*, dorsal views. *5*, ventral view of specimen with shell eroded. *6*, dorsal view of specimen with shell eroded. (p. 455)

7–12—*Atrypa spinosa* var. *montanensis* Kindle. Slategoat Mountain. *7, 9* and *11*, ventral views. *8, 10* and *12*, dorsal views. (p. 456)

13–15—*Spirifer engelmanni* Meek. Lone Butte and Slategoat mountains. *13*, ventral view. *14*, dorsal view. *15*, ventral view. (p. 457)

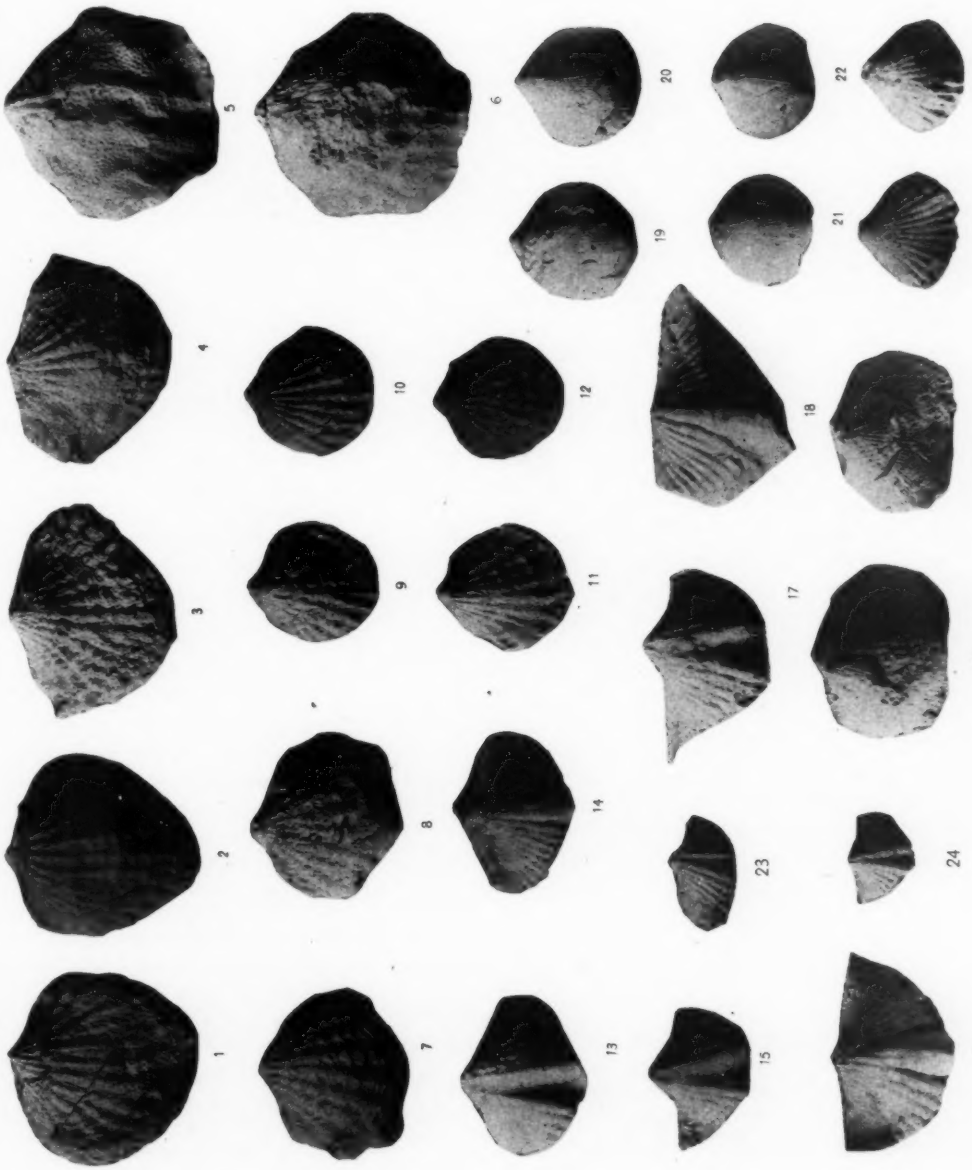
16–18—*Spirifer raymondi* Haynes. Pentagon, Lone Butte and Slategoat mountains. *16, 18*, dorsal views. *17*, ventral view. (p. 458)

19–22—*Atrypa missouriensis* Miller. Pentagon Mountain. *19, 21*, dorsal views. *20, 22*, ventral views. (p. 457)

23, 24—*Spirifer jasperensis* Warren. Lone Butte and Slategoat mountains. Both figures are ventral views. (p. 457)

25, 26—*Schizophoria iowaensis* (Hall). Lone Butte. *25*, dorsal view. *26*, ventral view. (p. 455)

27, 28—*Camaroloechia saxatilis* (Hall). Allan Mountain. *27*, ventral view. *28*, dorsal view. (p. 454



Laird, Devonian Brachiopods From Montana

UNIV. OF MICH.

covered by many more costae.

Occurrence.—All the specimens in my collection come from the Devonian unit Db on Slategoat Mountain.

ATRYPA MISSOURIENSIS Miller
Plate 64, figures 19–22

1894. *Atrypa missouriensis* MILLER, Geol. Survey Indiana, Eighteenth Ann. Report, p. 315, pl. 9, figs. 19–21.
1908. *Atrypa missouriensis* Miller, KINDLE, Bull. Am. Paleontology, vol. 4, no. 20, p. 29, pl. 1, figs. 7–7b.

Description.—Shell small, subcircular to nearly circular in outline. Slightly longer than wide, with an average length of 12 mm. for five well preserved specimens running from 11 to 14 mm. For five specimens the width averages 11.4 mm., running from 10 to 13 mm.

The shells are biconvex with only slightly elevated umbos on both valves. The greatest thickness is in the umbonal region and averages 6.4 mm. for five specimens, running from 5 to 8 mm. The beak of the pedicle valve slightly overhangs the cardinal area which is very small.

The surface of both valves is covered with 60–70 radiating striations which bifurcate toward the anterior margin of the valve. Indistinct growth lines concentric with the anterior edge are also present. A very indistinct medial sinus is present on the ventral valve with an opposing medial fold on the dorsal valve.

Remarks—This form is very distinct from *Atrypa montanensis* Kindle which is found at a similar stratigraphic horizon. This form has striations and an indistinct fold and sinus whereas *Atrypa montanensis* has coarse costae and a distinct medial fold and sinus.

Occurrence—All specimens come from the lower part of Devonian unit Db on Pentagon Mountain.

Genus SPIRIFER Sowerby
SPIRIFER ENGELMANNI Meek
Plate 64, figures 13–15

1860. *Spirifer engelmanni* MEEK, Philadelphia Acad. Nat. Sci., Pr., vol. 12, p. 308.
1884. *Spirifera engelmanni* Meek, WALCOTT, U. S. Geol. Survey Mon. 8, p. 138.
1940. *Spirifer engelmanni* Meek, MERRIAM, Geol. Soc. America Spec. Paper 25, p. 87, pl. 8, figs. 3, 4.

Description—This *Spirifer* is not as abundant as the other Spirifers in the present collection.

The valves have an average width of 11.5 mm., running from 7 to 17 mm. in width. The length is considerably shorter, running from 5 to 14 mm. and averaging 6.25 mm. Only one complete specimen with both valves was found. It was 8 mm. in thickness but is the largest specimen of this form in the collection.

The shells are subtriangular in shape and possess a high pointed beak on the ventral valve which only slightly overhangs the cardinal area in most forms. The cardinal area is high and slightly curved, the major portion of the area being on the ventral valve.

The surface of the valve is covered by rounded costae which are not as pronounced as in *Spirifer jasperensis, Spirifer argentarius* and *Spirifer raymondi.*

A shallow striated but not costated sinus is present on the ventral valve. On the dorsal valve a low striated median fold with shallow median furrow is present.

Remarks.—This form is similar in general appearance to *Spirifer jasperensis* Warren and *Spirifer argentarius* Meek except for the high cardinal area. This high cardinal area plus the high curved beak of the ventral valve serve to differentiate this form from the previously mentioned species.

Occurrence.—All the forms came from the Devonian unit Db on Lone Butte and Slategoat mountains.

SPIRIFER JASPERENSIS Warren
Plate 64, figures 23, 24

1932. *Spirifer jasperensis* WARREN, Roy. Soc. Canada Trans., vol. 26, sec. 4, p. 245–247, pl. 2, figs. 16–21.
1940. *Spirifer argentarius* Meek, MERRIAM, Geol. Soc. America Spec. Paper 25, p. 87, pl. 8, figs. 5–11.

Description.—The specimens at hand are all poorly preserved. The form, however, is stratigraphically important so deserves description.

The valves are small, averaging 9 mm. in width and 5.8 mm. in length. Unfortunately, no specimens were found having both valves together so measurements of thickness are not available. The ratio of the width to the length averages 1.55: 1. The cardinal area of

this form is distinct but lower and similar to that of *Spirifer raymondi* Haynes, although much smaller. It definitely does not have as high a cardinal area as *Spirifer engelmanni* Meek. The shell is not greatly elevated at the umbonal region and the beak of the ventral valve, while pronounced, does not overhang the cardinal area greatly.

The surfaces of the valves are covered with fairly sharp to subrounded costae. On the ventral valve the number of costae runs from 7 to 16 averaging 13. On the dorsal valve the average number of costae is 11.5. The ventral valve is marked by a distinct and sharply defined but moderately shallow sinus. This sinus is without costae. The dorsal valve has a less distinct fold which sometimes carries a poorly defined medial furrow. In only one specimen was there a suggestion of striations parallel to the costation of the valves.

Remarks.—It has been pointed out by Warren that this form is a variable species. There seems little but size to distinguish it from *Spirifer raymondi* Haynes. There is some question if this is a valid distinction. It appears to be identical with *Spirifer argentarius* Meek, as illustrated by Merriam. Inasmuch as these forms are found at very similar stratigraphic horizons, although geographically widely separated, it is entirely possible they are one and the same. Warren's name is being retained at present as his type locality seems to be in a very similar lithologic and ecologic province.

Spirifer jasperensis differs from *Spirifer engelmanni* Meek in having a much lower and less triangular cardinal area. *Spirifer engelmanni* in the specimens at hand also shows distinct striation parallel to the costae.

Occurrence.—The specimens studied all came from Devonian unit Db at Pentagon Mountain, Lone Butte, Slategoat Mountain and Allan Mountain.

SPIRIFER RAYMONDI Haynes
Plate 64, figures 16–18

1908. *Spirifer* cf. *argentarius* Meek, KINDLE, Bull. Am. Paleontology, no. 20, p. 32, pl. 2, fig. 4.
1916. *Spirifer raymondi* HAYNES, Carnegie Mus. Ann., vol. 10, pp. 31–33, pl. 5, figs. 1–2, pl. 6, figs. 12–13.

Description.—This *Spirifer* is most abundantly represented in the collections at hand.

The valves have an average width of 23 mm. within the limits of 16 to 44 mm. The length of the valve runs from 7 to 18 mm. averaging 13 mm. The ratio of width to length is about 1.80 to 1. Too few specimens showing both valves were found to make any positive statements as to thickness, but the average thickness of two specimens is 9 mm.

The shells are triangular in outline and some of the shells, particularly the larger ones, tend to be very alate.

The surface of the valves is covered with strong subrounded costae. The average number of costae on the ventral valve is 18, running from 14 to 26. The average number of costae on the dorsal valve is 17, running from 15 to 20. The number of costae appear to increase with the size of the individual. One specimen with 44 costae on the pedicle valve was excluded in computing the average. No striations parallel to the costae were observed. Growth lines concentric with the anterior part of the shell are indistinctly present in a few specimens.

The ventral valve is only moderately elevated in the umbonal region and has a distinct non-costate sinus. The dorsal valve is low, only slightly elevated, and has a somewhat flattened median fold. The cardinal area is flat and is not triangular in shape.

Remarks.—This seems clearly to be the same form described by Haynes. He notes, however, the presence of a slight fold in the middle of the sinus in his well-preserved specimens. None of the specimens at hand show this fold in the sinus.

The form illustrated by Kindle appears to be a typical *Spirifer raymondi* as found in the present fauna. With the exception of size, this form appears almost identical with the *Spirifer jasperensis* Warren which in turn appears to be identical with *Spirifer argentarius* Meek. Certainly much revision of the Spirifers of the Rocky Mountain area is needed.

Occurrence.—All the specimens collected came from the Devonian unit Db at Pentagon Mountain, Lone Butte, and Slategoat Mountain.

LIST OF LOCALITIES

Pentagon Mountain, Sec. 15, T. 25 N., R. 12 W., Montana.

Lone Butte, Sec. 23, T. 23 N., R. 13 W., Montana.

Slategoat Mountain, Sec. 10, T. 22 N., R. 11 W., Montana.

Allan Mountain, Sec. 20, T. 21 N., R. 9 W., Montana.

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TWO NEW GENERA OF PALEOZOIC GASTROPODA

L. A. NELSON
Texas College of Mines and Metallurgy, El Paso, Texas

ABSTRACT—Two new genera and six new species are erected. One genus is referred to the superfamily Pleurotomariacea; *Paragonoizona*, genotype *Paragoniozona nodolirata* Nelson; the species erected under this genus are: *Paragoniozona nodolirata* Nelson, n. sp.; *Paragoniozona paucinodosa* Nelson, n. sp.; *Paragoniozona multilirata* Nelson, n. sp.; *Paragoniozona sarlei*, Nelson, n. sp. The other genus is referred to superfamily Loxonematacea. *Callispira*, genotype *Callispira quinquecostata* Nelson. The species for this genus are: *Callispira quinquecostata* Nelson, n. sp., and *Callispira novemcostata* Nelson, n. sp.

THE Pennsylvanian (Magdalena group) of the Franklin Mountains of west Texas has yielded a rich gastropod fauna in an unusually excellent state of preservation (Nelson, 1937, p. 89; 1940, p. 157). The writer hopes to describe this fauna in its entirety as circumstances permit, but in the meantime, it will be useful to establish two new genera represented not only in this faunal realm but widely distributed in the Pennsylvanian faunas of the United States.

A description of the stratigraphic section showing the levels in the Magdalena beds from which the collections were made will be found in a previous paper (Nelson, 1940, p. 167).

During the latter part of December 1945 I had the pleasure of consulting with Dr. J. Brookes Knight, Research Associate in Paleontology, at the United States National Museum and I am deeply indebted to him for his most valuable suggestions and for the use of his photographic equipment. I also appreciate the many times Mr. J. K. Prather, El Paso, Texas accompanied me into the field and assisted in some of the collecting. Type specimens are deposited in the U. S. National Museum.

Superfamily PLEUROTOMARIACEA

GENUS PARAGONIOZONA Nelson, n. gen.

Pleurotomaria (in part), Meek and Worthen, 1866 (p. 356); (in part) of Sayre, 1930 (p. 130); and (in part) of Girty, 1934 (p. 259).

Genotype, PARAGONIOZONA NODOLIRATA Nelson, n. sp.

Description.—Small to medium, trochiform, anomphalus gastropods with well defined but shallow sutures and a selenizone situated just above the angulated periphery of the whorl; base nearly flat; whorl profile flatly rounded; inner lip somewhat reflexed with parietal inductura thin or wanting; outer lip with a broad, shallow sinus culminating in a slit of less than one-eighth a whorl circumference in depth; ornamentation on the whorl surface above the selenizone spiral lirae and transverse lirae or lines of growth. On species with transverse lirae nodes are developed where these intersect; on those with growth lines alone the nodes are wanting or very small. The ornamentation between the selenizone and the angle is generally not noded as is the upper surface. This area may show stronger development of the transverse lirae and in other cases the revolving lirae are shown to be the stronger. The basal surface does not show nodes or granules, the revolving lirae in each case being more strongly developed than the transverse lirae. The ornamentation of the selenizone varies somewhat according to the species; some forms have well developed rows of nodes which may be either bead-shaped or slightly elongated while other forms do not show nodes of any description; lunulae in most species are well developed, some closely spaced while others are spaced farther apart.

Comparisons.—The most closely similar genus is *Phymatopleura* Girty, 1939, under which he included the species *Phymatopleura nodosus* (Girty), the genotype, and *P. brazoensis* (Shumard). The respective descriptions of each of these two species indicate that the genus differs from *Paragoniozona* in that the former is minutely phaneromphalus; the parietal inductura is wanting and instead, much of the ornamented surface of the outer layer of the shell within the apertural region is actually re-

sorbed. The latter genus is anomphalus; the parietal inductura, although thin or wanting, does not show that the outer ornamented surface has been resorbed from the parietal lip. Both genera possess somewhat similar revolving and transverse markings, but on *Phymatopleura* the intersection of these lines produce nodes which generally are much coarser especially those along the upper margin of the whorl surface. The peripheral band, occupied by the selenizone in each case, is generally much wider on *Phymatopleura* than on *Paragoniozona*. I should like to place under *Paragoniozona* (new genus), besides the genotype, the American species *Pleurotomaria granulostriata* Meek and Worthen, 1866, from the Lower Coal Measures, Maucopin County, Illinois; *Pleurotomaria granulostriata* (?) Sayre, 1930, from the Westerville limestone member, Kansas City formation, Turner, Kansas; *Pleurotomaria aspera* Girty, 1934, from the Brentwood limestone member of the Boyd shale (early Pennsylvanian), Woolsey, Arkansas; *Pleurotomaria millegranosa* Girty, 1934, Brentwood limestone member of the Boyd shale (early Pennsylvanian), Cold Spring, Arkansas.

Range.—Mississippian?—Pennsylvanian.

PARAGONIOZONA NODOLIRATA
Nelson, n. sp.
Plate 65, figures 2a–c

Description.—Sides of the spire very slightly convex; anomphalus base flattened to slightly rounded, bordered by a roughened angulation; whorls 6–7 in number, somewhat compressed, much wider than high, upper margin of each slightly shouldered; suture well defined; selenizone impressed below the general surface, bounded by two revolving lirae, located near that angulation of the body whorl and visible just above the suture on the spire whorls; inner lip somewhat extended below and reflexed; upper whorl surface marked by five revolving lirae between the upper carina bounding the selenizone and the suture above, the transverse lirae more strongly developed near the suture than at the selenizone, the nodes more pronounced above and gradually decreasing in magnitude and finally disappearing as the upper carina bounding the selenizone is approached; the transverse lirae bend obliquely backward at suture above and descend across the whorl surface to the selenizone forming into a narrow slit then bend forward for a short distance and continue with slight backward obliquity and continue to the umbilical region; selenizone ornamented by vertically elongated nodes which are equally spaced and well developed, a revolving lira placed slightly below the middle of this zone; the transverse markings between the carina bounding the lower margin of the selenizone and the angle are strongly developed, elsewhere they are not pronounced; basal surface ornamented by 9 or 10 strong revolving costae, the width of the interspaces about twice the thickness of the costae; first two or three whorls smooth or with extremely fine revolving lirae only; length of a mature shell 8 mm. (assuming one whorl missing), width 6.5 mm.; pleural angle approximately 60°.

Comparisons.—*Paragoniozona nodolirata* Nelson is close to *P. granulostriata* (Meek and Worthen), except that the latter is slightly smaller, the revolving lines are fewer above the selenizone, the selenizone is less defined, and the whorl profile is apparently more rounded. *Paragoniozona millegranosa* (Girty), has a more rounded whorl profile, eight or nine noded revolving lirae on the upper whorl surface, more pronounced carinae bounding the selenizone, and a greater number of smaller nodes occupying the selenizone. In *P. paucinodosa* a band without ornamentation occupies the lower half of the upper whorl face. *P. multilirata* is without transverse lirae or conspicuous nodes. *P. sarlei* has transverse lirae slightly less in magnitude than the revolving lirae, the intersection of which forms a reticulated appearance upon the surface, selenizone without ornamentation.

Occurrence.—Magdalena group, bed 96, Strawn equivalent (early Pennsylvanian), Franklin Mountains, opposite Vinton, Texas.

PARAGONIOZONA PAUCINODOSA
Nelson, n. sp.
Plate 65, figures 3a–c

Description.—Sides of the spire very slightly convex; base flattened to slightly rounded, bounded by a roughened angulation, anomphalus; number of whorls seven or eight, the height slightly less than one-

half the width on the later whorls; whorl profile nearly straight or slightly convex; selenizone narrow, raised above the general surface, visible just above the suture, bordered by a single carina above and below, containing a single revolving lira situated in the middle, and also containing regularly spaced nodes which are either spheroidal or slightly elongated vertically; area below upper sutures slightly shouldered; columellar lip seemingly straight, slightly extended, and seemingly reflexed in some specimens to definitely reflexed in others; the margin of the outer lip extends obliquely backward from the shoulder on the upper whorl surface and continues to the selenizone, below which it bends forward and then gently backward and continues to the umbilicus; ornamentation varies somewhat, on some specimens the upper margin of the whorl surface has four or five revolving lirae, the first three of which are strongly nodose, the succeeding lira slightly nodose, the other, if present, is simple and not very prominent; the lower portion of the upper whorl surface above the selenizone is without revolving lirae, the narrow area between the lower carina bounding the selenizone and the angulation roughened by the moderately strong transverse lirae; other specimens show a wider smooth surface on the upper whorl face between the selenizone and the upper margin, only two noded revolving lirae appearing on the uppermost margin followed by one or a few very fine revolving lirae; base on all specimens covered with heavy, well spaced revolving lirae; the holotype measures 6.75 mm. (assuming one whorl missing) in height, 5 mm. in width at the base.

Comparisons.—*Paragoniozona paucinodosa* has a band without ornamentation occupying the lower half of the upper whorl face, the transverse lirae are present on this species and absent in *P. multilirata* which is without a visible noded surface. *P. sarlei* has both transverse and revolving lirae which are nearly equal in strength resulting in a reticulated appearance rather than the general noded surface and is considerably larger than the other species mentioned herein. *P. millegranosa* and *P. granulostriata* are noded on both the upper whorl surface and the selenizone area, and each has a more rounded whorl profile.

Occurrence.—Magdalena group, bed 96, Strawn equivalent (early Pennsylvanian), Franklin Mountains, opposite Vinton, Texas

PARAGONIOZONA SARLEI
Nelson, n. sp.
Plate 65, figure 5

Description.—Shell conical; sides of the spire very nearly straight; base flattened to slightly rounded, bordered by a fairly strong angulation, anomphalus; whorl profile nearly straight except for small interruption near lower part of upper whorl surface due to slight convexity of the selenizone; whorls flattened, height about one third the width; sutures shallow but well defined; selenizone prominent, slightly raised above the general surface of the whorl, lower margin bounded by a rather strong carina, the upper carina less pronounced, concave on the earlier whorls, convex on the later, lunulae well developed, closely spaced; columellar lip, although not seen, probably slightly extended below and slightly reflexed, parietal inductura thin; upper whorl surface ornamented with about 10 revolving lirae, the uppermost six of which are slightly coarser and spaced a little farther apart than the four just above the selenizone, a finer revolving lira is seen between two of the coarser lirae; base marked by about 25 rather irregular revolving lirae smaller in size than the majority of those on the upper whorl surface; the revolving lirae are crossed by fine, closely spaced transverse lirae which give a reticulated appearance to the upper three fourths of the whorl surface from the suture to the selenizone; below the selenizone the transverse lines are weaker and do not show reticulations where they cross the revolving lirae, although bunching of revolving lirae is plainly visible on the basal surface; growth lines and transverse lirae bend obliquely backward and continue across the upper surface of the whorl to the selenizone where they form in a shallow slit, after which they bend forward a short distance to the angulation and again sweep obliquely backward in a broad curve for a short distance, then sweep slightly forward and continue to the umbilical region. This incomplete shell consisting of four whorls measuring 15 mm. in height and 16.5 mm. in width across the body whorl, if entire would proba-

bly measure 21 mm. in height and would have seven or eight whorls.

Discussion.—This shell, the only specimen of its kind in my possession, was collected by Dr. C. J. Sarle from the Magdalena group of the Franklin Mountains. The exact locality is unknown to me but I have included it here to show the much larger size and range in ornamentation. The specimen here designated the holotype has been deposited with the United States National Museum and is numbered 111,954.

PARAGONIOZONA MULTILIRATA
Nelson, n. sp.
Plate 65, figures 4a–e

Description.—Small conical, trochiform gastropods with nearly straight to slightly convex sides and a slightly rounded anomphalus base; whorls six or seven, height of a mature shell about 11 mm., width 8 mm., pleural angle 40°–45°, the outer whorl surface straight or slightly concave above the angulation and the selenizone, the shoulder along the upper surface of the whorl and that near the basal angle interrupting the general slope which conforms to the angle of the spire, the surface below the angle rounded and continuing to the umbilicus; sutures prominent and fairly deeply incised; selenizone situated above the angulation and visible on the whorl face above the suture, impressed slightly below the whorl surface, without definite bounding lirae, with closely spaced lunulae and a few faintly visible revolving lirae, the central one the most pronounced; two prominent revolving lirae usually with a finer one between them at the basal angulation; outer lip bending obliquely backward beginning at the lower boundary of the shoulder and continuing across the upper whorl surface to the selenizone where there is a short slit, after which the curvature straightens somewhat forward but the general curvature remains backward, crossing the base and finally terminating in the umbilical region; columellar lip extended, inclined a little towards the aperture, reflexed; parietal inductura slightly thickened; ornamentation on upper whorl surface above the selenizone 12 to 16 fine revolving closely spaced lirae, a double line forming the first lira below the upper suture; the transverse markings seem to be growth lines only, thus no nodes or conspicuous reticulations are visibly developed, the lira below the lower boundary of the selenizone rather prominent; base with 25–30 pronounced revolving lirae persisting to the umbilical region, occasional transverse wrinkles present on both the upper whorl and basal surfaces.

Comparisons.—This species has the general characteristics of the genus. The ornamentation, however, is without nodes and represents one end of the series of the species assigned to the genus *Paragoniozona*, *P. granulostriata* (Meek and Worthen) being on the other end of the series. *P. sarlei* is closely related to this species but differs in that it is considerably larger, the selenizone is raised above the whorl surface, the transverse lirae are plainly visible, and the whorl surface between the selenizone and the upper suture is reticulated.

Occurrence.—Magdalena group, Strawn equivalent (early Pennsylvanian); one, the holotype, from bed 73, opposite Vinton, Texas; one collected by Dr. C. J. Sarle, from the same group; several from bed 96, opposite Vinton, Texas; and two from the same group, north of Anthony Pass, opposite Anthony, New Mexico. All specimens are from the Franklin Mountains.

Superfamily LOXONEMATACEA
GENUS CALLISPIRA Nelson, n. gen.

Genotype, *Callispira quinquecostata* Nelson, n. sp.

Diagnosis.—High-spired, many whorled loxonematoid gastropods of medium to small size with five to nine revolving carinae or lirae and a broad, very slight sinus in the outer lip; whorl profile slightly convex; sutures shallow, slightly to deeply impressed; base gently rounded, anomphalus; columellar lip slightly reflexed; parietal inductura thin; shell thick, composed of two layers; ornamentation on whorl surface between sutures revolving costae or lirae, crossed only by growth-lines, the base with weaker lirae or costae.

Comparisons.—*Callispira* somewhat resembles *Donaldina* as far as revolving lirae are concerned and there is some resemblance in the outer lip except that the latter has a pronounced sinus while that of *Callispira* is more nearly straight. The nucleus of

Donaldina is characteristically heterostrophic while that of *Callispira* is orthostrophic. The shell is much larger and thicker, the whorl profile not so convex, and the pleural angle greater in *Callispira*. Species of *Stegocoelia*, such as *S. wortheni* Knight, are closely similar but *Stegocoelia* is a murchisonid with a typical murchisonid slit and selenizone.

Range.—Pennsylvanian.

CALLISPIRA QUINQUECOSTATA
Nelson, n. sp.
Plate 65, figures 6a–b

Description.—In addition to the characteristics of the genus. Estimated height of the holotype 15.5 mm., width 7.5 mm., number of whorls eight or nine; width of whorls about twice their height. Through the generosity of Mr. R. J. Stark the U. S. National Museum has recently acquired a specimen from the Milsap Lake formation, Strawn group, from south of Santo, Palo Pinto Co., Texas (USNM 111947), which is more nearly complete than the holotype. Dr. Knight's measurements of this specimen are: height 24 mm., width 11.4 mm., number of whorls 12, pleural angle 31°. The upper whorl surface just below the suture is slightly concave to the first revolving costa, slightly convex over the middle of the whorl, the margin of the curvature interrupted by the prominent revolving costae, below which the profile is slightly concave to a costa lower on the lower whorl surface; whorl profile well rounded in the early stages but becoming less so on the later whorls; ornamentation on the exposed whorl surface five revolving costae, on the early whorls these being smaller and regularly spaced while on the later whorls they increase in size. This species has one revolving costa a slight distance below the upper suture line, below this three larger ones nearly equally spaced, and a fourth slightly smaller one below these which can be seen just above the suture on all whorls; base with two or three very obscure scarcely visible costae; growth lines very fine and closely spaced, beginning at the suture with slight obliquity backward to the first costa where the curvature bends forward and continues about parallel with the axis of the shell to the last costa and across the base to the umbilicus; shell unusually thick and composed of two layers, the outer one very thin.

Comparisons.—*Callispira novemcostata* Nelson, n. sp. is the only other described species of this genus known to me. It is much smaller, has deeper sutures and more numerous revolving costae.

Occurrence.—Magdalena group, Strawn

EXPLANATION OF PLATE 65

FIG. 1—*Paragoniozona millegranosa* (Girty). A side view of the holotype ×4. This shows a species with extremely well developed and numerous nodes. (p. 461)

2a–c—*Paragoniozona nodolirata* Nelson, n. sp. *a*, *b*, the holotype (USNM 111,951), ×4, side and basal views respectively. Note the difference in nodal arrangement on both the upper surface of the whorl and on the selenizone. *c*, a small paratype ×4, side view, slightly distorted. (p. 461)

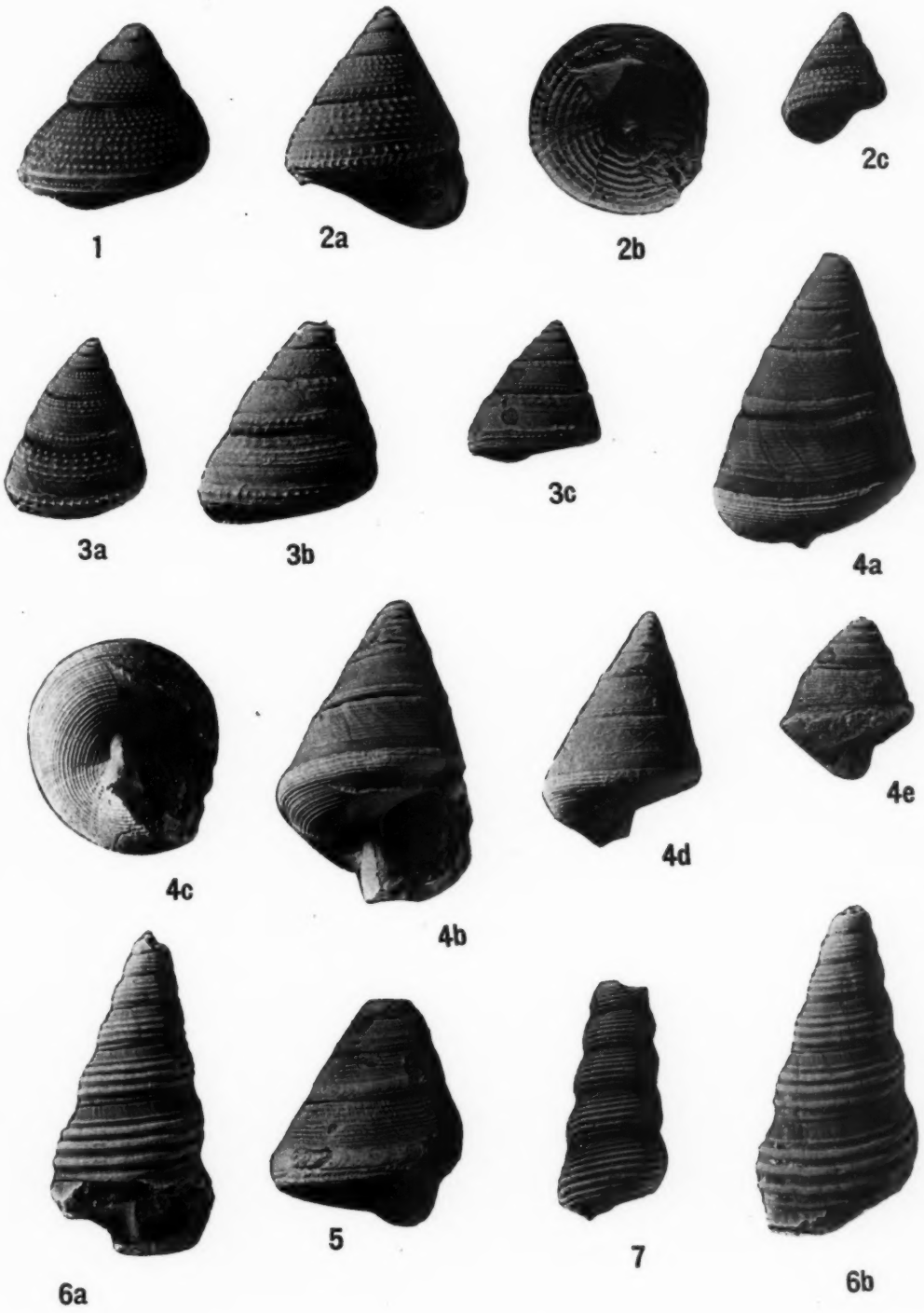
3a–c—*Paragoniozona paucinodosa* Nelson, n. sp. *a*, the holotype (USNM 111,952), ×4, view slightly oblique. *b*, a paratype (USNM 111,953), ×4, side view of a slightly larger specimen. *c*, a paratype (USNM, 111,953), ×4, side view to show reduction in number of revolving lirae and nodes. (p. 461)

4a–e—*Paragoniozona multilirata* Nelson, n. sp. *a*, *b*, *c*, the holotype (USNM 111,950), ×4, side and basal views respectively of a large specimen, *a*, *b* show the revolving lirae. In this species the nodes are completely missing. *a*, oblique side view, showing the extended and reflexed columellar lip and the slightly thickened inductura. *d*, a specimen collected by Dr. C. J. Sarle, ×4, the surface partially weathered and representing an average size individual. *e*, side view, ×6, of a juvenile form, slightly distorted. (p. 463)

5—*Paragoniozona sarlei* Nelson, n. sp. The holotype (USNM 111,954), ×2, side view of a specimen of a rather large species for the genus. The specimen was collected by Dr. C. J. Sarle, from the Magdalena group, Franklin Mountains. (p. 462)

6a–b—*Callispira quinquecostata* Nelson, n. sp. *a*, *b*, side views of the holotype (USNM 111,948), ×3¾. Note especially the thickness of the shell. (p. 464)

7—*Callispira novemcostata* Nelson, n. sp. The holotype (USNM 111,949), ×6, side view. (p. 465)



Nelson, Paleozoic Gastropods

equivalent (early Pennsylvanian); the paratype, from bed 96, opposite Vinton, Texas; the holotype, from the same group, north of Anthony Pass, opposite Anthony, New Mexico. Both from the Franklin Mountains.

CALLISPIRA NOVEMCOSTATA
Nelson, n. sp.
Plate 65, figure 7

Description.—Small, high-spired, many whorled gastropods with numerous revolving costae; whorl profile rounded, sutures rather deeply impressed; apex and aperture not well known; base gently rounded, anomphalus; growth lines and, therefore, outer lip indistinct; parietal inductura thin; ornamentation with nine revolving costae on each whorl between suture lines, the two revolving costae just below the upper suture line being fine and the sixth, seventh and eighth stronger than the others. The spaces between the costae are about equal to or slightly less than the thickness of the costae. The transverse growth lines are not visible on the surface of the shell.

Remarks.—The figured incomplete specimen, the only one in my collection consists of five whorls with the revolving lines well preserved; width of whorl about twice its height; estimated height of a complete shell 8–9 mm., pleural angle 15°.

MANUSCRIPT RECEIVED AUGUST 27, 1946

Comparisons.—Compared to *Callispira quinquecostata* Nelson this species is much smaller in size, the shell is thinner, and the revolving costae are more numerous but smaller and the arrangement somewhat different on the surface of the whorls.

Occurrence.—Magdalena group, Strawn equivalent, bed 96, Franklin Mountains, opposite Vinton, Texas.

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JOURNAL OF PALEONTOLOGY, VOL. 21, NO. 5, PP. 466–472, PLS. 66–69, 2 TEXT-FIGS., SEPTEMBER 1947

INVERTEBRATE TRACKS FROM THE COCONINO SANDSTONE OF NORTHERN ARIZONA

L. F. BRADY
Museum of Northern Arizona, Flagstaff

ABSTRACT—Variations are noted in the tracks of two invertebrates described by Gilmore from the Coconino sandstone. Comparison with tracks of living arthropods suggests that *Paleohelcura* almost certainly, and probably *Octopodichnus* as well, should be referred to scorpionids. Three other forms are tentatively referred to representatives of the Diplopoda, Isopoda and Oligochaeta, and the new genera *Diplopodichnus*, *Isopodichnus* and *Scolecocoprus* are erected to receive them.

WHILE the numerous and striking vertebrate tracks found in the Coconino sandstone have received a great deal of notice from paleontologists and laymen, the smaller and less common invertebrate tracks have been somewhat neglected.

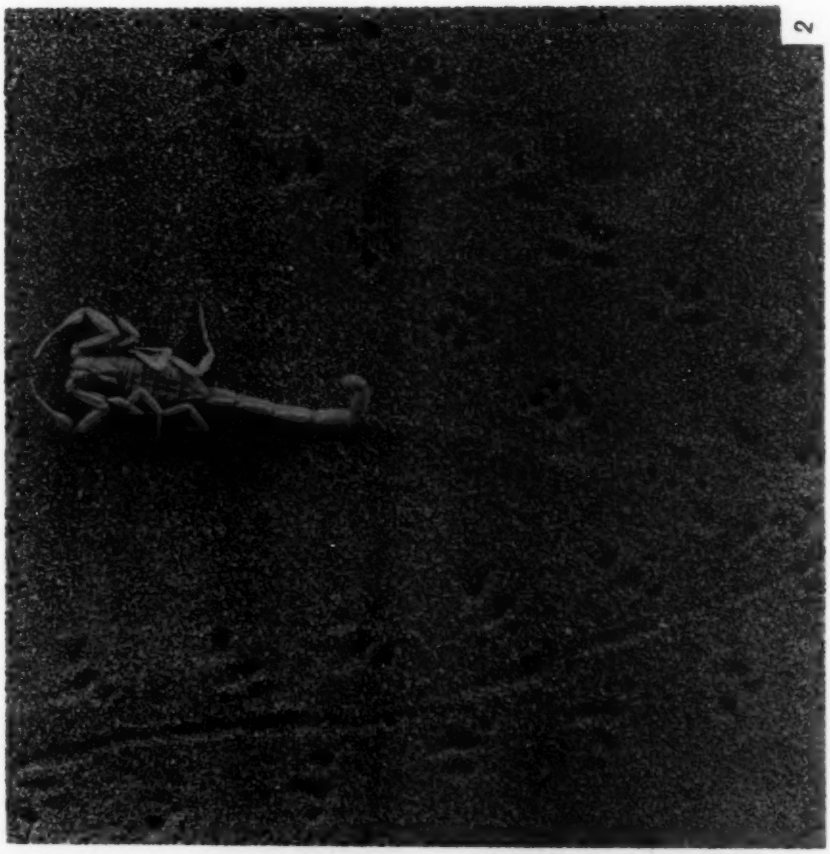
Gilmore (1926, 1927) described several, but without any attempt to refer them to any particular type of animal.

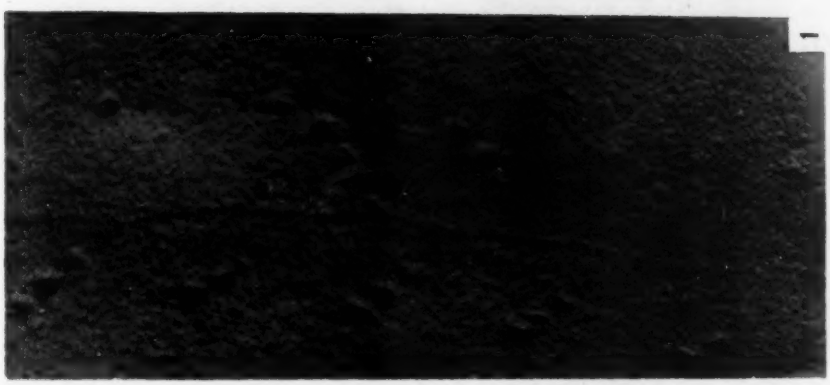
In the course of studies of modern dune environment for comparison with that of the Permian dune formations, experiments have been carried on at intervals for several years at the Museum of Northern Arizona with invertebrates of many kinds in an effort to find the origin of these and other tracks. Collections of track material made from numerous localities show interesting variations in two forms, *Paleohelcura* and *Octopodichnus*, described in the above mentioned papers, and include a number of undescribed tracks.

One of the commonest invertebrate tracks found in the Coconino sandstone is that described by Gilmore as *Paleohelcura tridactyla* (Plate 66, fig. 1). As this form, when complete, shows six impressing feet and a tail drag, it seemed probable at first that an nsect of some kind was responsible. However, no insect with which experiment was made left a track in any way similar. One track of *Paleohelcura* over 30 cm. long, suggested a possible solution. In this specimen the track begins with the normal form, but later turns to the left; just before the turn the pattern of the foot impression changes and during the turn the tail drag swings inward almost to the inner limit of the track (Plate 67, fig. 1). As this suggested an arthropod having a long tail with some lateral flexibility, such as a scorpion, and as one foot group showed a clear impression of a fourth foot on one side, experiments were made with several species of scorpions. These were found to make tracks which vary considerably with different conditions of temperature, surface, etc., but occasionally tracks were made which were very similar to *Paleohelcura*. On wet sand *Centruroides*. the scorpion which seemed most satisfactory, refused to move. On a slightly moist sand surface it left no track at all, owing to the cohesion of the sand grains. On dry sand at a temperature of 8° C. the animal was slightly torpid and impressed all four feet on each side, but left no tail drag. At about 15° C. it made tracks very like the fossil form, but at 20° C. or higher, became excited and made confused, irregular tracks. Plate 66, figure 2 shows tracks made by *Centruroides sculpturatus* on a 10 degree slope at two different temperatures. The front pair of walking legs does not impress at temperatures at which normal locomotion was observed. In the light of the resemblance between the tracks of *Cen-*

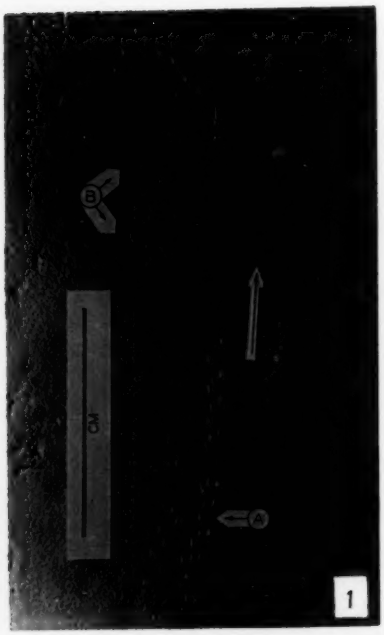
EXPLANATION OF PLATE 66

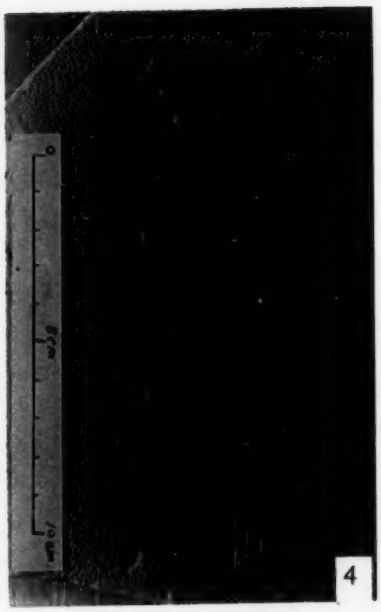
FIG. *1*—*Paleohelcura tridactyla* Gilmore. The holotype (U. S. Nat. Mus. 11145), ×1. (p. 466)
2—*Centruroides sculpturatus* and tracks on recent sand dune. The left hand track was made at 15° C., the right hand one at 8° C., when the scorpion was slightly torpid, ×1. (p. 466)

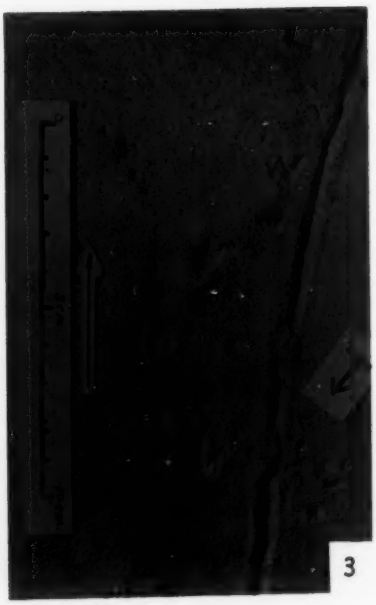




Brady, Coconino Sandstone Invertebrate Tracks







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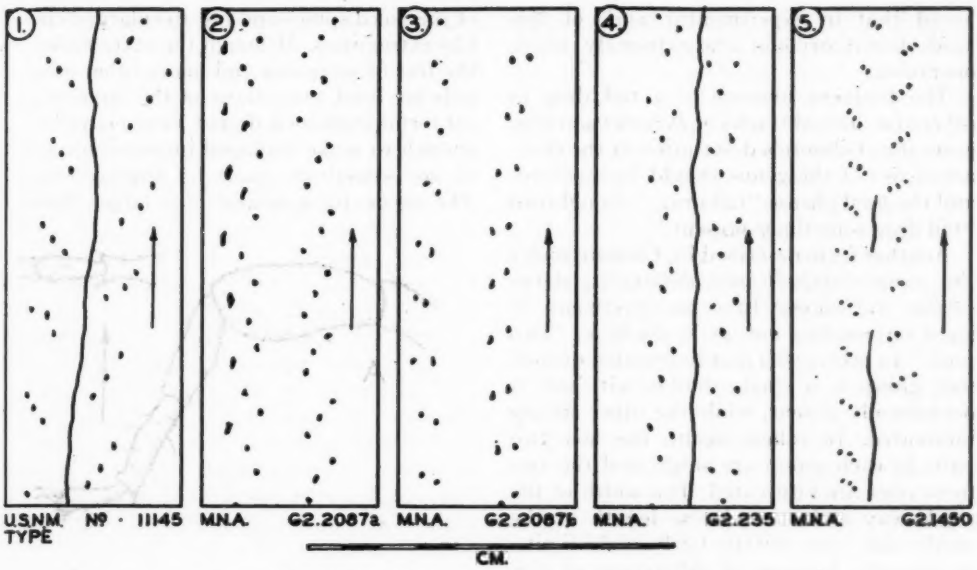

FIG. *1*—Variation in tracks of *Paleohelcura tridactyla* Gilmore.

truroides and *Paleohelcura*, it would seem that the latter should be tentatively referred to a member of the Scorpionida.

Several of the tracks of this type in the collection of the Museum show no tail drag at all. In others the tail drag is interrupted or very faint, while some show impressions of only two feet on each side. Others show somewhat different patterns of foot impressions and some variations in the width of track and relative length of stride. On a recent field trip over twenty tracks were observed which should be referred to this species, but of these only three showed a continuous tail drag, and one an occasional trace of one. Ten of the tracks showed foot groups of two impressions either throughout, or in part of their length. Of half a dozen such tracks in the collection of the Grand Canyon Museum, only one has a complete tail drag. A specimen (G2.235) in the collection of the Museum of Northern Arizona has the foot impressions arranged as triangles. Others show the normal linear arrangement as a rule, with occasional triangular groups. On rare occasions an impression of a fourth foot is found in a group. With reference to the frequent absence of a tail drag in tracks otherwise similar to those of *Paleohelcura*, it may be noted that of five species of Arizona scorpions observed, *Centruroides sculpturatus* is the only one which made any tail drag. Moreover, the larger tropical forms, as far as the writer has noticed, always carry the tail arched over the back when moving normally.

It seems, however, very doubtful that any new species should be erected for such variations, which may well be due to differences of temperature, surface condition and slope, and possibly the disposition of the animal (Figure 1). In this connection it may be

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EXPLANATION OF PLATE 67

FIG. *1*—Track of *Paleohelcura tridactyla* Gilmore, showing displaced tail drag on turn at B. A fourth foot impression is visible at A. ×0.3. (p. 466)

2—Track of *Octopodichnus didactylus* Gilmore. The holotype (U. S. Nat. Mus.), ×0.3. (p. 468)

3—*Octopodichnus didactylus* Gilmore. A single foot group (left side) of an unusually large specimen (MNA G2.2688), ×½. The long groove is not part of this track. (p. 468)

4—*Octopodichnus minor* Brady, n. sp. The holotype (MNA G2.2082), ×½. (p. 469)

noted that in experimental work of this kind, live scorpions are extremely uncooperative.

The frequent absence of a tail drag in otherwise normal tracks of *Paleohelcura* suggests that Gilmore's description of the characteristics of the genus should be modified, and the final phrase "tail drag," should read "tail drag sometimes present."

Another form described by Gilmore under the name *Octopodichnus didactylus*, shows similar variations. In some specimens all eight impressions are, as in the type, "two toed." In others, the first impression of each foot group is a single shallow pit, and is occasionally absent, while the other six are bifurcated. In others again, the last two pairs in each group are single and the two front ones are bifurcated. The width of the track way and the relative length of the stride also vary within fairly wide limits, presumably because of differences of size and age. The largest specimen of the Museum collection (G2.2688) has very deep impressions, a track width of 115 mm. and a "stride" of 140 mm. The corresponding measurements of the type are 94 mm. and 106 mm.; and of the smallest one (G2.222) in the Museum collection 82 mm. and 89 mm. Individual foot impressions vary from the deep impressions of over 1 cm. long (G2.2688) with some considerable backward displacement of sand, to a mere series of single or double pits, about 1 to 3 mm. long. In view of the above variations in the track of *Octopodichnus* observed in the study of over a dozen specimens it would seem advisable to make some change in the generic definition. Gilmore's description, based on the type and one other poorly preserved specimen, reads, "Apparently eight footed, with tracks arranged in groups of four, alternating, two anterior impressions didactyle, two posterior unidactyle." The following definition is proposed to include the variations mentioned above. "The track of an eight footed animal, with individual impressions arranged in alternating groups of four. Any of the individual foot prints may be simple elongated impressions or may be apparently prints of a didactyle or even tridactyle extremity" (Plate 67, figs. 2, 3).

It seems to the writer that the two apparent "toes," are due to the development of the basal spines and not to enlarged claw-like extremities. Although the extremities of the feet of scorpions and many other arachnids are bifid, even those of the large tropical forms examined do not have claws large enough to make v-shaped impressions, such as are sometimes made by *Octopodichnus*. The claws, for example, of a large African

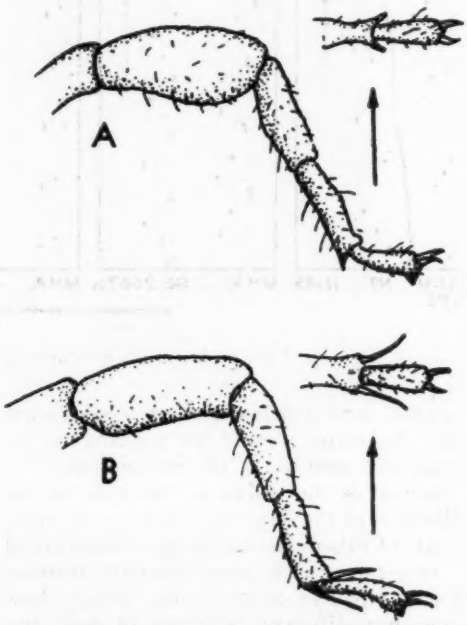


FIG. 2—(*A*), Extremity of fourth walking leg of *Hadrurus*, with two basal spurs, and top view of tarsus, ×2. (*B*), Suggested form of corresponding portions of limb of *Octopodichnus*, and top view of tarsus, ×2/3. In recent forms the tarsal spines appear to be fixed, but in *Octopodichnus* they were apparently movable.

form, *Pandinus*, are less than 2 mm. in length and the bifurcate impression of the foot of *Octopodichnus didactylus*, an animal of apparently less than twice the size, is sometimes as much as 15 mm. long. Moreover the two sides of the v-shaped impressions are never equal in *Octopodichnus* as are the claws of the scorpion's foot, or those of any other arachnid with bifid extremities. Some of the foot prints show distinct impressions of a basal spine on each side of the foot, resembling the print of a trifid extremity. This is also the case in the type specimen.

It is frequently possible to determine the approximate direction of movement of the animal which made these tracks with reference to the slope of the surface, by noting the displacement of the sand behind the foot, and it is significant that when the animal is moving at an angle to the dip of the surface, the shorter arm of the "v" almost invariably points up the slope. This would suggest the use of either one of a pair of movable basal spines rather than the widely separated "digits" of a bifid foot. In a few cases impressions of the foot of *Octopodichnus* resemble a small shoe, with no bifurcation; the "sole" being the mark of the whole distal segment of the limb, and the "heel" being that of the tarsal joint (Plate 69, fig. 4). As the larger tropical scorpions do not, as far as the writer has observed, drag their tails, and as in walking the weight is taken on the whole distal segment of the limb and not on the tip, *Octopodichnus* may very possibly be the track of a large scorpionid with well-developed and movable basal spines. Figure 2 suggests its possible foot structure.

A smaller form of the track which may be referred to the genus *Octopodichnus* is different from *O. didactylus* not only in size, but in the pattern of the foot groups. It is accordingly described as a new species.

ARTHROPODA

?SCORPIONIDA

OCTOPODICHNUS MINOR

Brady, n. sp.

Plate 67, figure 4; plate 69, figure 5

Holotype.—MNA G2.2082, small slab of sandstone about 18×10×2 cm. with a track showing six complete groups of foot impressions, two on the right side and four on the left.

Paratype.—MNA G2.229, a slab 30×10×3 cm. with a complete track along its entire length.

Occurrence.—About three miles north of Seligman, Arizona; Coconino sandstone.

Description.—Impressions of all four feet on each side in definite well-spaced groups. No tail drag observed. Impressions of feet #1 and #2 (counting from the front of each group) and occasionally #3 are bifurcated; #4 is a simple oval pit. The line of impressions 4–3–2 is approximately straight, and diverges from the line of travel at an angle of about 35 to 40 degrees, as in *Paleohelcura*. The line of impressions #1 and #2 turns back toward the line of travel, forming an angle of 90 to 100 degrees with the line 4–3–2 (in *O. didactylus* Gilmore the line 4–3 diverges and the line 3–2–1 converges toward the center line). In the type the distances between the individual foot impresions vary as follows: 1–2, 12 to 14 mm.; 2–3, 5 to 7 mm.; 3–2, 9 to 10 mm. The average width of the track is 50 mm, and the "stride" 44 mm. In the paratype the corresponding measurements are about 20 per cent smaller. All the tracks studied are remarkably straight.

Remarks.—If the forms described above are correctly attributed to scorpions, and if the ratio of track width and stride to the length of the animal was the same as in the case of recent forms, their body lengths appear to have been as follows:

Paleohelcura tridactyla	4– 5 cm.	
Octopodichnus minor	8–10 cm.	
Octopodichnus didactylus	18–22 cm.	Possibly up to 28 or 30 cm.

Four other types of tracks of invertebrates are sufficiently like those of known recent forms to be worth recording under new names suggested by the resemblances. In the absence of more definite evidence or of organic remains, no more than tentative reference to natural orders can be made.

ARTHROPODA

?DIPLOPODA

Genus DIPLOPODICHNUS Brady, n. gen.

Tracks consisting of two or three parallel grooves without distinct foot marks. A narrow low ridge separates each pair of grooves. Genotype, *Diplopodichnus biformis* Brady, n. sp.

DIPLOPODICHNUS BIFORMIS Brady, n. sp.

Plate 69, figure 4

Holotype.—MNA. G2.228, a slab 30×18×1 cm. showing numerous trails each about 15 cm. long.

Occurrence.—About three miles north of Seligman, Arizona; Coconino sandstone, Middle Permian.

Description.—The name is given to a form of long continuous tracks which are not uncommon in the Coconino sandstone. The tracks are of two types which almost invariably occur together. A narrow form about 4 mm. in width, consists of two parallel grooves, while the wider form, about 6 mm. wide, has three grooves, with a lateral ridge on either side. Occasionally faint foot impressions are visible in the two outer grooves. These two forms are strikingly similar to the tracks of a millipede, as observed in the course of experiments on arthropod tracks on recent sand dunes. The two-grooved form was seen to be made, as a rule, by the animal going up the slope of a dune and the wider three-grooved one was made on the downward trip (Plate 68, fig. 2).

Remarks.—Apparently the body was held clear of the sand when the two-grooved form was made. In the three-grooved form the median groove may have been made by the under side of the body, or possibly by an appendage at the hind end of the animal, serving as a brake.

Although somewhat similar tracks on a much smaller scale are made today by small beetles, and probably by other small insects, none of these have been observed of a size comparable to the ones described above.

Blattids large enough to make such tracks invariably leave definite well spaced foot impressions without the continuous grooves. None of the smaller recent forms which were observed to make tracks similar in size to that under discussion, are known from Paleozoic formations.

The type therefore has been named for the recent arthropod making the most nearly similar tracks, and the animal responsible for them is tentatively referred to the Diplopoda.

With reference to this form, a trackway from the Coconino sandstone (USNM 11,497) at Grand Canyon was referred by Gilmore (1927, p. 34) to Hitchcock's genus *Unisulcus* under the name of *Unisulcus sinuosus.* This trackway, as Gilmore observed, is not consistently one-grooved. He writes, "slightly beyond the intersection of two of these trails both are flattened and widened out and the bottom is sculptured by three distinct shallow, longitudinal grooves." It would seem probable, in the light of the rather frequent occurrence of the two- and three-grooved tracks, that Gilmore's specimen should be referred to the new genus *Diplopodichnus* rather than to *Unisulcus.*

It is worth noting that this type of track occurs very frequently at a horizon near the base of the Coconino sandstone, as well as at the horizon about 120 feet above the base at which most of the vertebrate tracks are found.

ARTHROPODA

?ISOPODA

Genus ISOPODICHNUS Brady, n. gen.

Track consisting of a low sinuous median ridge with a row of closely set linear foot prints on either side, the prints not reaching to the ridge and sloping slightly forward of the perpendicular to it. Genotype, *Isopodichnus filiciformis* Brady, n. sp.

ISOPODICHNUS FILICIFORMIS Brady, n. sp.
Plate 68, figure 3

Holotype.—MNA G2.2089, a small slab of sandstone about 22 × 16 × 1.2 cm., showing a somewhat weathered winding track 18 cm. in length (Plate 3, fig. 3).

Occurrence.—About three miles north of Seligman, Arizona; Coconino sandstone.

The type track, which is continuous across the face of the slab, consists of a low central ridge with numerous forward pointing, bract-like impressions on each side at intervals of about 1 mm. forming a trail about 1 cm. wide.

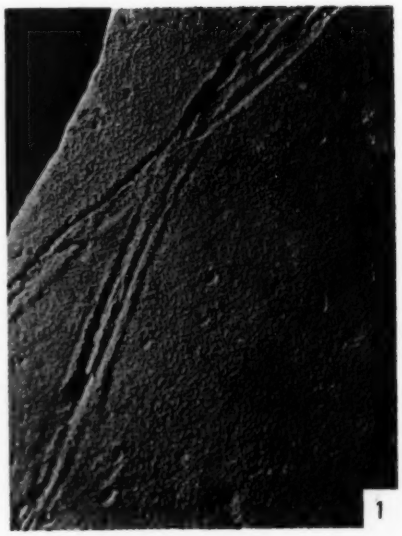
EXPLANATION OF PLATE 68

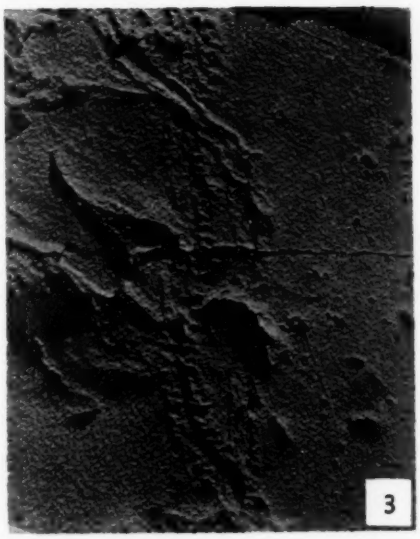
FIG. *1*—*Diplopodichnus biformis* Brady, n. sp. Form with two grooves (MNA G2.236), × ½. (p. 469)

2—Track of recent millipede, *Aristreptus coltoni* Chamberlin, on sand dune for comparison with *Diplopodichnus*, × ½. (p. 470)

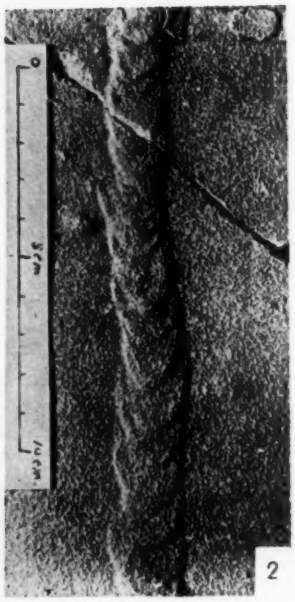
3—*Isopodichnus filiciformis* Brady, n. sp. Holotype, × ½. An imperfect track of *Paleohelcura* on right. (p. 470)

4—Track of recent isopod, *Oniscus* sp., on road dust, for comparison with *Isopodichnus*, × ½. (p. 471)





Brady, Coconino Sandstone Invertebrate Tracks



Brady, Coconino Sandstone Invertebrate Tracks

The marked similarity of this track to that of the isopod *Onicus* (Plate 68, fig. 4) on recent sand suggests the above generic name, and the resemblance of the first observed specimen (on a small fragment of rock) to a fern impression provides the specific name.

ANNELIDA

?OLIGOCHAETA

Genus SCOLECOCOPRUS Brady, n. gen.

A series of more or less elliptic, closely packed pellets, probably of fecal origin, filling burrows approximately circular in cross section. Genotype, *Scolecocoprus cameronensis* Brady, n. sp.

SCOLECOCOPRUS CAMERONENSIS
Brady, n. sp.
Plate 69, figure 1

Holotype.—MNA G2.236, a small slab of sandstone with about 60 cm. of worm-like material exposed on the surface.

Occurrence.—Little Colorado canyon, about 6 miles below Cameron, Arizona; Coconino sandstone.

Description.—A series of cylindrical sandy masses, about 15 mm. in diameter, resembling large fecal pellets, each one overlapping by about 5 mm. the rounded end of the one previously expelled, and leaving an exposed length of about 10 to 25 mm. between the grooves which mark the limits of the overlap. The whole gives somewhat the appearance of a long irregularly segmented worm.

Remarks.—On the sandstone slab (about 23×18×7 cm.) containing the type specimen about 60 cm. of such series of pellets are exposed on the upper surface. Several others are also visible here and there at lower levels, exposed along the edges.

In at least two cases series of pellets pass through previously deposited ones. This fact and the irregularly undulating nature of the series make it evident that the pellets were deposited under and not on the surface of the sand. Moreover the overlapping of each pellet on the preceding one suggests deposition beneath the surface, where each pellet was held firmly in place while the next one was pushed against it.

The specimen suggests strongly the sand ingested by a large oligochete worm, and expelled intermittently in the burrow. While it is true that recent earthworms, as far as the writer has been able to ascertain, rise to the surface and deposit the egested material in continuous coils in the open air, it may reasonably be supposed that a similar animal living in a sand dune environment, probably at sufficient depth to find fairly damp sand, would have to ingest a very large amount of material in order to supply itself with enough nourishment, and would not be able, on account of the looseness of the sand, to maintain a permanent burrow like those of recent earthworms. For either or both of these reasons such a form might be supposed to have adopted the habit of continuous ingestion, and of egesting the waste material at intervals behind it as it moved beneath the surface.

The suggested name accordingly is based on the supposition that the specimen represents the fecal pellets of a large worm, possibly an oligochete, of habits peculiarly adapted to a dune environment.

Similar specimens in the Museum collection, found in the Coconino sandstone, a few miles north of Ash Fork and near Seligman, Arizona, represent a closely related form.

EXPLANATION OF PLATE 69

FIG. *1*—*Scolecocoprus cameronensis* Brady, n. sp. Holotype (MNA G2.236), ×0.4. (p. 471)

2—*Scolecocoprus arizonensis* Brady, n. sp. Holotype (MNA G2.230), showing closely packed fecal pellets, ×½. (p. 472)

3—*Scolecocoprus arizonensis* Brady, n. sp. Paratype (MNA G2.2687), showing grooved bottom of burrow on under side of slab, ×0.3. (p. 472)

4—*Diplopodichnus biformis* Brady, n. sp. Holotype (MNA G2.228), with two and three-grooved forms, ×½. Left side of *Octopodichnus minor* on left; imperfect track of *Paleohelcura* on right, partly obliterating the right side of the larger track. (p. 469)

5—*Octopodichnus minor* Brady, n. sp. A paratype (MNA G2.229), ×½. (p. 469)

SCOLECOCOPRUS ARIZONENSIS
Brady, n. sp.
Plate 69, figures 2, 3

Holotype.—MNA G2.230, a small slab of sandstone 32×15×5 cm., with a series of overlapping pellets extending in an almost straight line for 21 cm. Figure 2.

Paratype.—MNA G2.2687, a slab, showing on the upper side several tube fillings with faint "pellet structure," and on the under side, four emerging burrows with smooth upper surface, and deeply grooved lower surface. Figure 3.

Occurrence.—About 10 miles north of Ash Fork, Arizona; Coconino sandstone.

Description.—General structure and diameter much like that of the preceding species, but pellets shorter and overlapping more at the top and bottom than at the sides. The general appearance from above is that of imbricating elliptic plates. On a number of slabs examined, the lower side of the burrow is seen to be marked by two deep longitudinal grooves. The burrows occasionally, as in the type, follow the interface between two slabs of sandstone and then pass at a low angle through several successive laminae. One was traced through six layers, a total vertical distance of about 10 cm. The overlapping pellet structure is often very much obscured and is sometimes unrecognizable. The suggestion is offered that the grooves referred to above are due to dragging of the two lower rows of setae as the hinder end of the worm is pulled forward.

In the course of correspondence with the writer, Dr. J. Percy Moore states that in his opinion the above suggestion is probably unsound, for the reason that recent oligochetes retract the ventral setae completely as the hinder end of the animal is dragged forward. The writer wishes to emphasize the very tentative nature of the suggested reference of *Scolecocoprus* to the Oligochaeta.

MANUSCRIPT RECEIVED JANUARY 3, 1947

NOTE ON TECHNIQUE

If it is desired to preserve specimens of small tracks on a surface of dust or loose sand, the following technique has been found very satisfactory. The surface is first sprayed lightly with a fine mist of a thin solution of shellac in alcohol, or better of a vinyl acetate plastic, or bakelite. Care must of course be taken not to disturb the surface by too strong an air blast. After a few minutes the surface is again sprayed somewhat more heavily and allowed to dry. A thin film of sand may then be raised with a large spatula (a flapjack turner serves excellently) and turned over. If half an inch or so of plaster of Paris is then poured on the back of the film, a very durable specimen results, especially if a polymerizing resin has been used. The specimens illustrated on Plate 66, figure 2, and Plate 68, figures 2 and 4 were prepared in this way.

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JOURNAL OF PALEONTOLOGY, VOL. 21, NO. 5, PP. 473–475, 6 TEXT FIGS., SEPTEMBER 1947

A NEW JURASSIC STOMECHINUS FROM THE BIG HORN BASIN, WYOMING

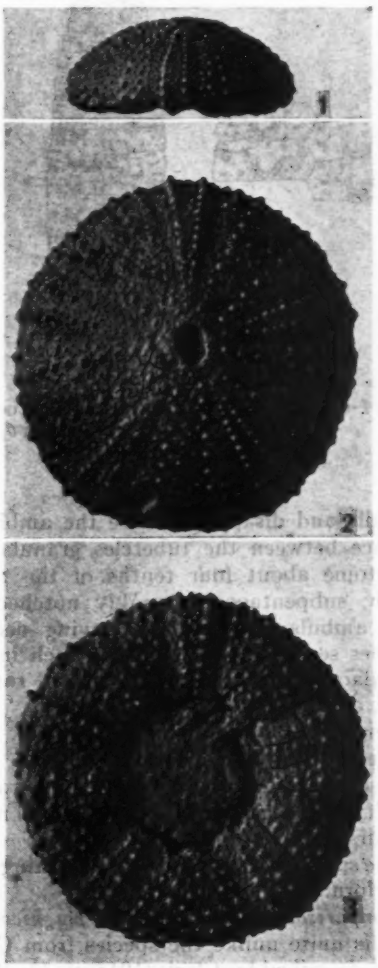
C. WYTHE COOKE
U. S. Geological Survey, Washington, D. C.

THE Jurassic deposits of the Rocky Mountain States have yielded few echinoderms. Clark (1915) describes three crinoids, two stelleroids, and one echinoid (*Holectypus pealei* Clark) from north of Berry Creek, Yellowstone National Park. Miller (1928) adds one echinoid (*Hemicidaris sundancensis* Miller) from the valley of Baldwin Creek about 6½ miles northwest of Lander, Wyoming, and later (1929) another (*Ancylocidaris spenceri* Miller) from Bull Lake Canyon about 30 miles northwest of Lander, for which he erects a new genus.[1] To these are now added an echinoid representing the genus *Stomechinus* Desor, 1856.

Collections made by field parties of the U. S. Geological Survey during the past ten years include pentagonal columnal plates of crinoids, impressions of a *Hemicidaris?*, part of a petaloidal ambulacral area of a large echinoid (possibly *Clypeus* or *Pygurus*), and several fairly well preserved specimens of the echinoid here described as *Stomechinus magnicornicolus*. All are supposed to have come from the same faunal zone, which lies between red beds formerly referred to the Sundance or the Chugwater formation. The zone is now placed within the Gypsum Spring formation, of Middle Jurassic age. Dr. Ralph Imlay informs me that the probable European equivalent is the Bajocian stage.

STOMECHINUS MAGNICORNICOLUS Cooke, n. sp.
Figures 1–6

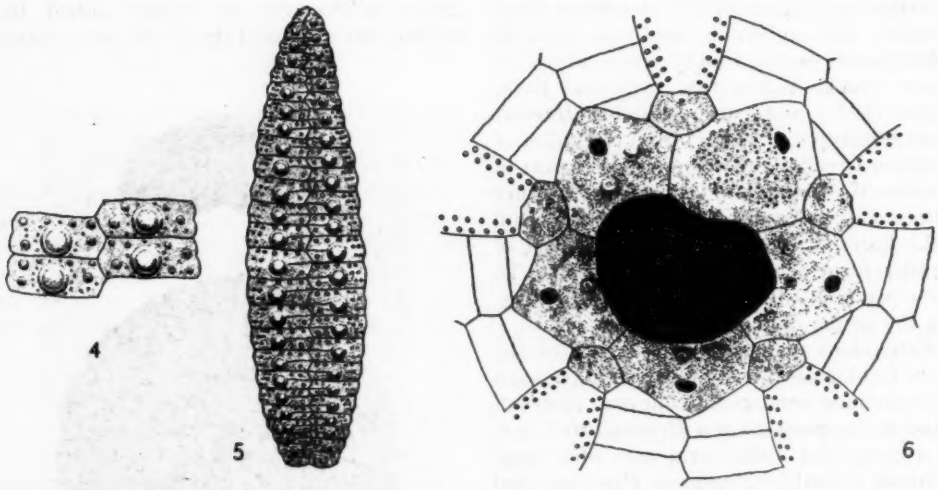
Test medium-sized, low-arched, circular or subpentagonal, flat-bottomed. Apical system large, dicyclic; genital plates much larger than the oculars, with salient points forming together a five-pointed star, the madreporite swollen and encroaching on the periproct. Ambulacral areas about half as wide as the interambulacral areas; poriferous zones trigeminate, the two or three groups nearest the apex nearly alined, the subsequent groups of three zygopores diago-



FIGS. *1–3*—*Stomechinus magnicornicolus* Cooke, n. sp. *1*, ×1; *2*, *3*, ×1½. Photographs by Nelson W. Shupe.

[1] *Ancylocidaris* is evidently not related to the Cidaridae, to which Miller refers it, for its ambulacral areas are too wide. It should be compared with *Orthopsis*.

nal; interporiferous zones bordered on each side by a continuous row of rather small primary imperforate tubercles, one to each compound plate, median area bearing two rows of smaller tubercles, which dwindle and disappear away from the ambitus. Interambulacral areas bearing two continuous rows of similar tubercles and several additional short rows that cover the base but dwindle and disappear above the ambitus. Surface between the tubercles granulated. Peristome about four tenths of the total width, subpentagonal, weakly notched in each ambulacral area and having deeper notches separated by a lobe in each interambulacral area. Periproct central, rather large, asymmetrical.



FIGS. *4–6*—*Stomechinus magnicornicolus* Cooke, n. sp. *4*, Part of an interambulacral area, enlarged; *5*, an ambulacral area, enlarged; *6*, the apical system, enlarged. Drawings by Elinor Stromberg. (p. 473).

Height 13 mm., diameter 32 mm., diameter of peristome 13.7 mm.

Disconnected spines from the typical locality are decorated with longitudinal rows of coarse nodes.

The specific name signifies "inhabiting the Big Horn."

Comparisons.—*Stomechinus magnicornicolus* is quite unlike the species from California described by Clark (1915, p. 33, pl. 5, fig. 2) as *Stomechinus hyatti*, whose generic identification is suspect. It more closely resembles the genotype, *S. bigranularis* (Lamarck), as figured by Cotteau (1881, p. 679, pl. 446), but it is lower and its peristome is proportionately larger. In decoration and in the shape and size of its peristome it is much like the Bajocian specimens of *S. serratus* (Agassiz) figured by Cotteau (1881, p. 711, pl. 456, figs. 3–9), but it is somewhat more depressed. No authentic specimens of either of these European Jurassic species are available for comparison.

Occurrence.—USGS 17651 (types) and 17670: East side of Sykes Mountain, sec. 12, T. 57 N., R. 95 W., northeastern part of the Big Horn Basin, Wyoming, 9 to 17 feet above the lower redbed member of the Gypsum Spring formation, D. A. Andrews, collector. USGS 19613: Five Mile Creek, Pryor Mountains, Montana, Carl Rogers, William Saulfrank, and Ralph Imlay, collectors. USGS 19630: East Boulder River south of Big Timber, Montana, Louis Gardner and party, collectors.

Geologic horizon.—Middle Jurassic, Gypsum Spring formation.

Types.—USNM 104174A (holotype) and 104174B (paratype).

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JOURNAL OF PALEONTOLOGY, VOL. 21, NO. 5, PP. 476–479, PLS. 70, 71, 3 TEXT FIGS., SEPTEMBER 1947

NAUTILUS BLAKEI, A NEW OLIGOCENE MOLLUSK FROM PALESTINE

M. AVNIMELECH
Hebrew University, Jersualem, Palestine

MORE than 20 years ago, rocks of Oligocene age, considered at the time as Miocene, were discovered in two localities in the hilly foreland in western Palestine, one near the town of Ramle (fig. 1), the other in the region of Bet Govrin (Beit Jibrin). Since then several new Oligocene outcrops have been recognized and it has been revealed that the extent of this formation is far larger than formerly supposed. This was somewhat surprising, as only a few years before it was rather believed that during Oligocene times all of Palestine was a land area.

This formation was first mentioned by the late G. S. Blake (1928) as Miocene and later (1930), as Oligocene or Miocene. These suggestions were based on the existence of *Lepidocyclina*, recognized by R. B. Newton and subsequently by A. Morley Davies. The first detailed account of the fauna of this formation, originating mainly from a quarry near Ramle, and partly from the area of Bet Govrin, was published by L. R. Cox (1934. Later (Avnimelech, 1936) I published additional data. Stampian and Aquitanian horizons were proved to occur there.

The fauna discussed by Cox was represented by one cephalopod, five gastropods, 14 Lamellibranchia and one foraminifer. I added to this last many characteristic Foraminifera. The cephalopod mentioned by Cox is a species of *Nautilus* compared by him with *N. piersantii* Venzo from the Chattian (upper Stampian) of Monte Brione in Trentino, north Italy, and with the Miocene *N. allionii* Michelotti. Several years later, S. Venzo (1937) in his memoir on the Chattian fauna from the glauconitic formation of Belluno (north Italy) supposed that the Palestinian *Nautilus* was *N. decipiens* Michelotti. This supposition was based only on the description of Cox, as

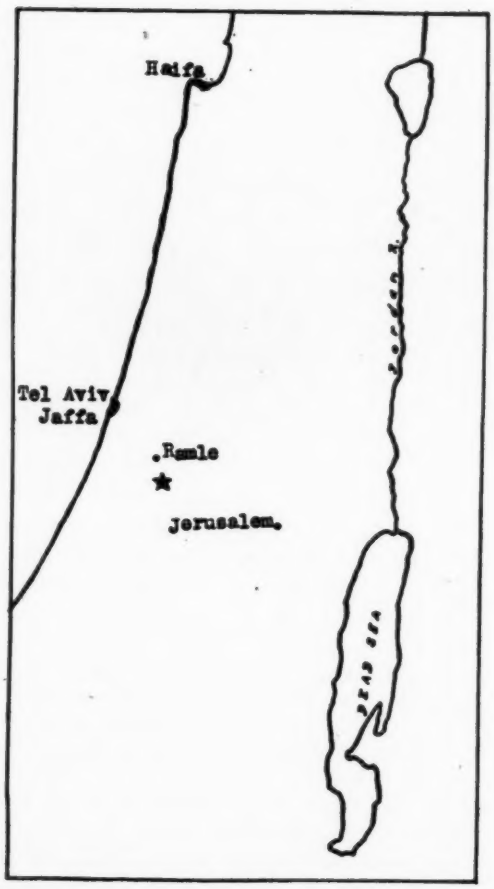
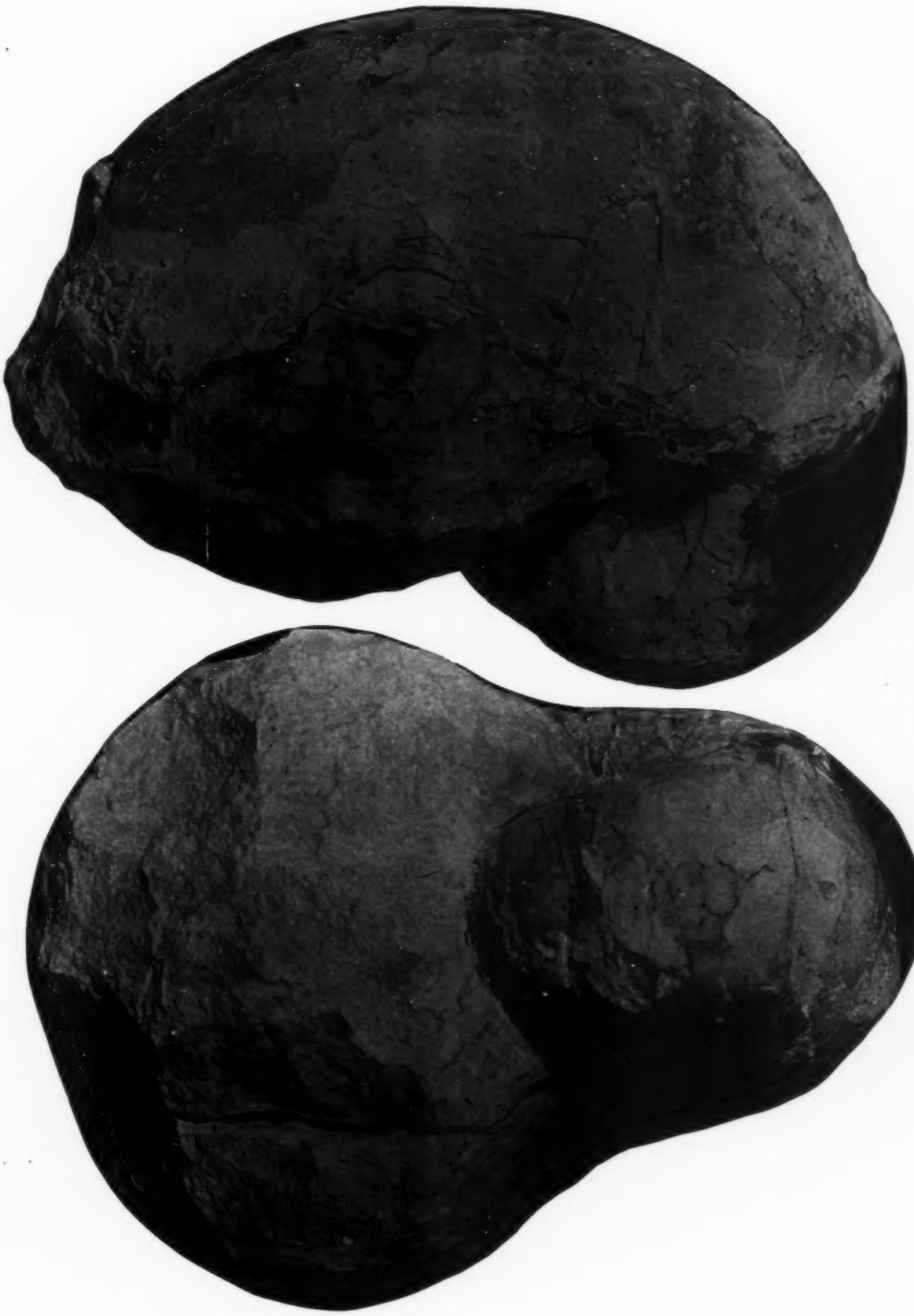


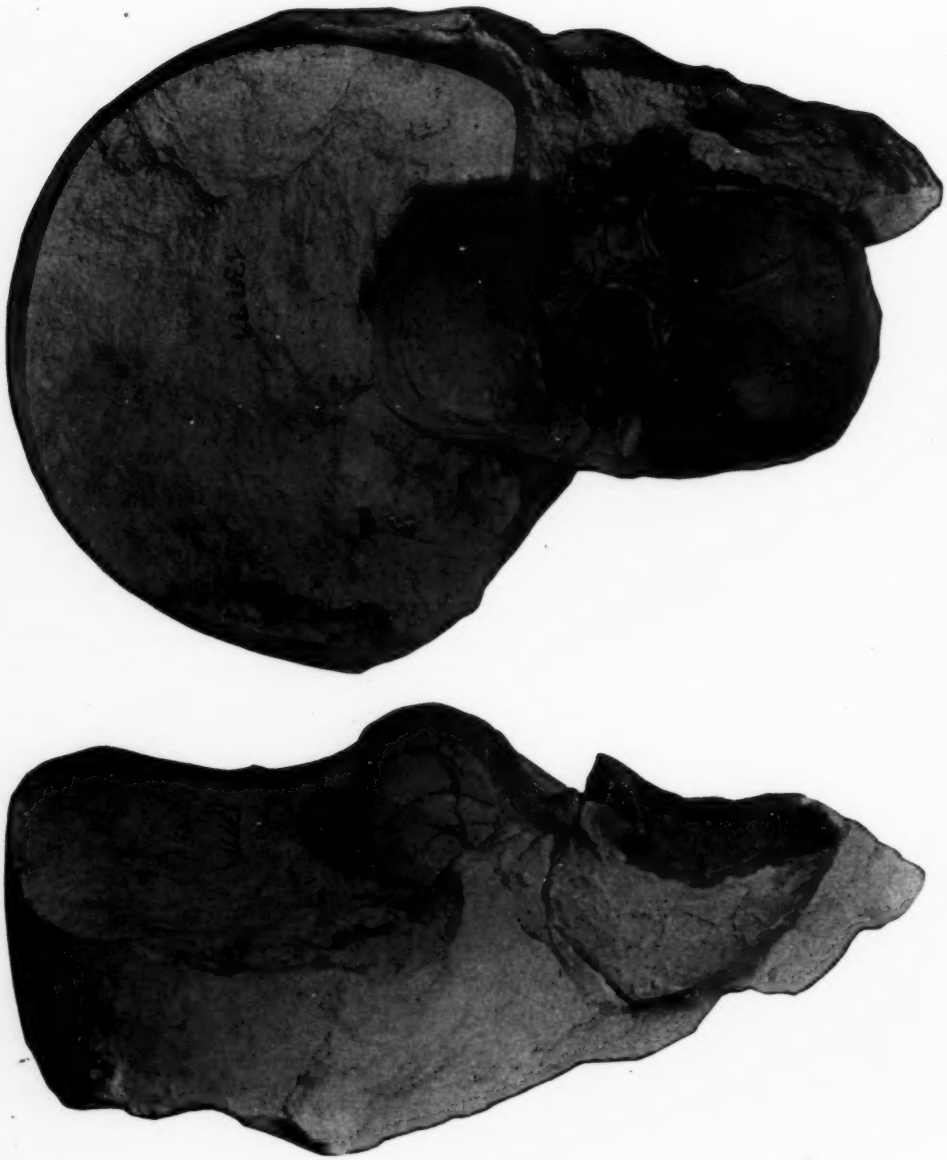
FIG. 1—Sketch map showing location of the *Nautilus*-bearing Oligocene outcrop south of Ramle.

EXPLANATION OF PLATE 70

FIGS. 1, 2—*Nautilus blakei* Avnimelech, n. sp. Ventral and lateral views of holotype (Geol. Section, Public Works Dept., Palestine Government, Jerusalem), somewhat reduced. From upper Oligocene of Ramle, Palestine. (p. 477)



Nautilus blakei Avnimelech, n. sp.



Nautilus blakei Avnimelech, n. sp.

no figure of the specimen had been given.

The description of Cox[1] was based on a single specimen deposited in the British Museum (Natural History) under Reg. No. C. 36408. In the collections of the Geological Section of the Public Works Department, Jerusalem, there is another specimen, representing a nearly complete cast made of hard white limestone. In the collections of the Geological Department of the Hebrew University, Jerusalem, three fragments of the same *Nautilus* are preserved representing parts of the inner whorls. So it is possible to complete the description of Cox and attain a more exact view of the nature of the fossil. As Oligocene Nautili are relatively rare throughout the world, any addition to the knowledge about them is of more than local interest.

NAUTILUS BLAKEI Avnimelech, n. sp.
Plates 70, 71; text figure 3

The following description is based mainly on the specimen deposited in collections of the Geological Section, Public Works Department, Jerusalem.

Nautilicone, very large; compressed in earlier stages, but somewhat inflated in gerontic stages; the greater diameter (d1, fig. 2), measured from the ventral margin of the aperture to the opposite end and passing through the umbilicus, 180 mm.; the smaller diameter (d2), normal to the former, 120 mm.; diameter of the penultimate half-whorl (d3), 95 mm.; diameter increase ratio for half a coiling, 1.9; in the other, fragmental specimen this ratio is for younger volutions 135/80 or 1.7. Larger radius (in the

[1] "Large and inflated, measuring 135 mm. in diameter and 90 mm. in thickness at the aperture. Whorls subquadrate in cross section, wider than high, flattened laterally and very broadly rounded ventrally. Umbilicus narrow and deep. Sutures flexuous laterally, but nearly straight where they cross the broad periphery. Siphuncle dorsocentral."

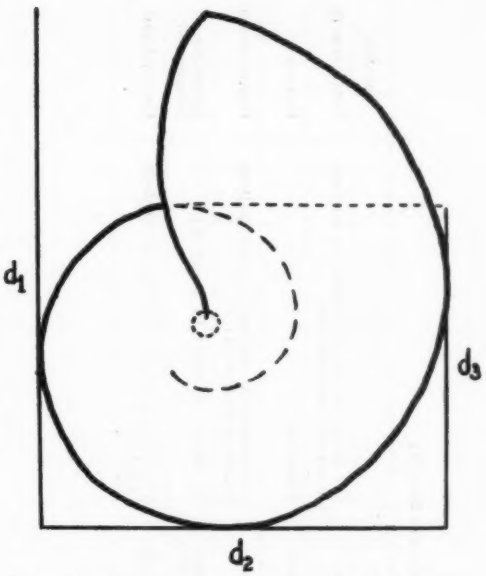


FIG. 2—Diagrammatic representation of diameters of a *Nautilus* shell as measured in the present description.

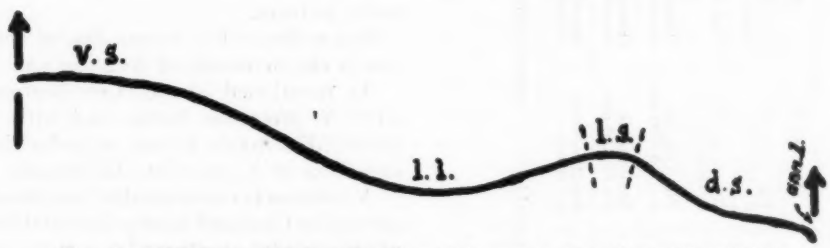


FIG. 3—Diagrammatic representation of the suture line of *Nautilus blakei* Avnimelech, n. sp.

EXPLANATION OF PLATE 71

FIGS. 1, 2—*Nautilus blakei* Avnimelech, n. sp. Ventral and lateral views of paratype (Geol. Dept., Hebrew Univ., Jerusalem, no. 13771), somewhat reduced. From upper Oligocene of Ramle, Palestine. (p. 477)

TABLE 1.—COMPARISON OF SOME OLIGOCENE AND MIOCENE NAUTILI

	Age	Dimensions	Shape	Aperture	Umbilicus	Sutures	Siphuncle
N. blakei	Upp. Olig.	Big, very big d = 180 mm	Oval, compressed inflated	Subquadrate	Very narrow, steep, deep	v.s. broad; l.l. broad-shallow; l.s. medium broad; d.l. medium deep.	Centro-dorsal
N. piersantii	Upp. Olig.	Big, very big d = 160 mm	Oval, inflated	Broad-oval	Medium-broad, deep	Unknown	Unknown
N. vinassai	Upp. Olig.	Big, very big d = 175–220 mm	Discoidal, compressed	High-oval	Narrow, steep deep.	v.s. medium broad, low; l.l. very shallow; l.s. small, shallow; d.l. ?	Centro-ventral
N. decipiens	Upp. Olig. Low. Mioc.	Medium-big d = 75–110 mm.	Discoidal-oval, compressed	High-oval	Medium-broad, funnel-like, deep.	v.s. broad; l.l. broad; l.s. broad; d.l. ?	Centro-dorsal to subdorsal
N. allionii	Miocene	Small-medium d = 50 mm	Discoidal, compressed	High-oval, trapezoidal	Medium-broad, funnel-like.	v.s. very broad; l.l. shallow; l.s. medium broad; d.l. ?	Centro-dorsal

v.s. = ventral saddle; l.l. = lateral lobe; l.s. = lateral saddle; d.l. = dorsal lobe.

sense of Stenzel, 1940), is 110 mm., smaller radius 52 mm., increase ratio for half a whorl nearly 2. Greatest width of the whorl (= width of the aperture), 130 mm., width of the former whorl at the base of the aperture, 50 mm., the width increase ratio for a whorl being 130/50, or 2.6; the same ratio for younger volutions of other specimen is 90/30 = 3.

In the early stages the whorls are subquadrate in cross section and almost as wide as high, but later they become wider and the ephebic-gerontic whorl may be described as ventrally broadly rounded and laterally inflated. The umbilicus in mature whorls is narrow and deep, but in the younger it is broader, so that the margins of earlier volutions can be observed.

Sutures (fig. 3) (not sufficiently well revealed in the big, complete specimen) are composed of a broad ventral saddle, broad, gentle lateral lobe, medium broad lateral saddle at the shoulder, and broad, medium-deep dorsal lobe with a very small (not clearly visible), insignificant conical annular lobe. The lateral lobe is deeper in younger whorls, and becomes shallower and broader in ephebic and gerontic whorls. Siphuncle in younger stages dorso-central, in later rather central.

The living chamber occupies nearly a quarter of a whorl.

The ventral margin of the aperture shows a deep and broad hyponomic sinus.

A small fragment of the outer impression shows regular incremental lines, obviously wavy in form.

Discussion.—The suture line of this species is characteristic of *Nautilus* s.s.

As mentioned above, Cox compared it with *N. piersantii* Venzo and with *N. allionii* Michelotti; Venzo regarded it as a synonym of *N. decipiens* Michelotti.

N. allionii is much smaller (as already observed by Cox) and nearly discoidal in form, of trapezoidal aperture. Its sutures are less sinuous, the lateral saddle being less deep. The umbilicus is broader, funnellike, in contrast with the almost vertical shoulders of our fossil. This species is very near to *N. vicentinus* (de Zigno) Oppenheim from the Upper Eocene of Priabona. *N. vicentinus* differs from the former by its more rounded ventrum and by its quite broad, nearly vertical umbilicus.

N. decipiens is also different: its form is discoidal-compressed, the whorls are round in cross section, the suture line differs, the lateral lobe being more distant from the umbilicus shoulder and being also less deep.

The nearest species is *N. piersantii*, not only through similarly large proportions but also through its form. Unfortunately its sutures are unknown and therefore its generic relations are not clear. Externally it differs from our fossil in its more rounded whorls and laterally very inflated form. Nevertheless it is not certain that the two are not specifically identical, and the differences between them may be an expression of sexual dimorphism.

The other giant *Nautilus* of the same horizon, *N. vinassai*, is different in its general form, its sutures and the centroventral position of the siphuncle.

N. regalis J. de C. Sowerby is of very similar shape.

For the reasons explained the *Nautilus* of Ramle is regarded as a new species. It is named *N. blakei* in memory of the late G. S. Blake, Geological Advisor to the Palestinian Government and later consulting oil geologist to the Palestine Mining Co., who has contributed a great deal to the geological knowledge of Palestine.

Nautilus blakei is compared with other Oligocene and Miocene species in the accompanying table.

Stratigraphical position.—*Nautilus blakei* occurs in upper Oligocene beds, but it is not certainly known, whether it is limited to the Aquitanian alone or if it occurs in the upper Stampian (Chattian) as well. Other upper Oligocene species are *N. piersantii*, *N. vinassai* and *N. decipiens*.

In the rock matrix of one of the fragments several specimens of *Operculina complanata heterostegina* Silvestri and *Lepidocyclina* (*Nephrolepidina*) *tournoueri* Lemoine & R. Douvillé were found. All these Foraminifera are very common in both the upper Stampian and the Aquitanian.

Type specimens.—The big, almost complete specimen (without registration number), deposited in the Geological Museum of Public Works Department, Jerusalem, was chosen as holotype. The specimen described by Cox and preserved in British Museum (Natural History) under No. C. 36408 is a topotype. The specimens of the Collections of the Geological Department, Hebrew University, Jerusalem, are registered under no. 13771. All these specimens are from the same place near Ramle.

Acknowledgments.—I am indebted to Mr. G. S. Shaw, Geological Adviser to the Palestine Government, for lending me the fossil which was chosen here as holotype; to Prof. S. Venzo, Milano, for sending me a figure and description of his *N. piersantii*; to Dr. L. R. Cox, London, for information on the *Nautilus* from Ramle, preserved in the British Museum.

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RECEIVED OCTOBER 4, 1946

JOURNAL OF PALEONTOLOGY, VOL. 21, NO. 5, PP. 480–483, 1 TEXT FIG., SEPTEMBER 1947

A CONTINENTAL TERTIARY TIME CHART

GEORGE GAYLORD SIMPSON
The American Museum of Natural History and Columbia University, New York

ABSTRACT—A Tertiary time chart intended primarily for studies of fossil mammals and their faunal associates is presented. Parallel columns give absolute ages in millions of years, world standard epochs and their subdivisions, South American provincial ages, North American provincial ages, European provincial ages, central and eastern Asiatic mammalian local faunas, south Asiatic mammal-bearing formations, and African mammalian local faunas. It is emphasized that, although such a compilation is useful and necessary, the intercontinental correlations and the absolute time scale are highly unreliable and subjective in the present state of knowledge.

STUDENTS of Tertiary stratigraphy and fossils in general and of Tertiary mammals in particular have continual need to consider (a) the sequence and nomenclature of continental and mammal-bearing beds and their faunas within the various continents and faunal provinces, (b) the approximate correlation of these beds and faunas among the continents and provinces, and (c) the relative durations and absolute ages of the temporal and stratigraphic units involved. The accompanying chart was developed to fill these needs for class use and in my own researches. In spite of its admittedly personal and subjective elements and other shortcomings, it is now published for its possible use by others, if only as a basis for discussion, improvement, and adaptation to other individual needs and opinions. (The drafting of the chart is by Miss Marie Bohrn.)

Vertical distances on the chart have been made roughly proportional to absolute time. Seventy-five million years has been taken as the total duration of the Cenozoic. According to A. Knopf (*in lit.*) the only reasonably firm radioactivity-method dating in this part of geological time is the now classic figure 60,000,000 years, which has usually been taken as the beginning of the Tertiary but which is now believed to fall somewhere near the Paleocene-Eocene boundary. The most probable duration of the Cenozoic is therefore 60,000,000 years plus the length of the Paleocene. The length of the Paleocene is unknown, but most American students of this epoch (as canvassed from time to time by letter and in person) agree that it was nearly as long as the Eocene. There is even more general agreement that the Eocene includes well over one-fourth of post-Paleocene time. It is thus improbable that the Paleocene was shorter than 15,000,000 years. Assumption of a duration much greater than this figure would, however, involve difficulties by shortening, probably to an undue extent, the available time for the Mesozoic periods. The duration of the Cenozoic is therefore taken as 60,000,000 (fixed radioactivity date) plus 15,000,000 (allowance for Paleocene older than fixed date) = 75,000,000 years.

The absolute dates and lengths of the Cenozoic epochs as shown on the chart were reached by dividing 75,000,000 years into six parts according to an opinion as to the relative lengths of the Tertiary epochs. The length of the Pleistocene, almost negligible on this scale, is taken as 1,000,000 years, an arbitrary figure but one widely accepted as reasonable. The relative lengths of the five Tertiary epochs involve a large element of personal, subjective judgment. This judgment is based primarily on mammalian evolution, considered in several different ways: numbers of successive, distinguishable mammalian faunas, degrees of morphological and taxonomic change in faunas as a whole and in selected, continuing phyla (especially, but not exclusively, in the Equidae), internal and collateral evidence of variations in rates of evolution, etc. Thicknesses of strata and other physical criteria of duration of time were also considered, but were not heavily weighted. From discussion with other students of the Tertiary, it has also appeared that there is a consensus that the duration sequence is Eocene > Paleocene > Miocene

TIME SCALE FOR TERTIARY MAMMALS

AND ASSOCIATED ROCKS AND FAUNAS

AGE	EPOCHS +		SOUTH AMERICA -ages-	NORTH AMERICA -ages-	EUROPE -ages-	CENT. & E. ASIA -local faunas-	SOUTH ASIA -formations-	AFRICA -local faunas-		EPOCHS	AGE
0	PLEISTOCENE									PLEISTOCENE	0
5	PLIOCENE	L	Chapadmalalan	Blancan	Villafranchian / Astian	Nihowan	Pinjor	?	L	PLIOCENE	5
		M	Montehermosan	Hemphillian	Plaisancian	Ertemte	Tatrot	Klein Zee	M		
10		M	Tunuyanian				Dhok Pathan				10
		E	Huayquerian	Clarendonian	Pontian	Paoto	Nagri	Wadi Natrûn	E		
15	MIOCENE	L	Mesopotamian	Barstovian	Sarmatian	Tung Gur	Chinji	?	L	MIOCENE	15
		M	Chasicoan	Hemingfordian	Vindobonian / Tortonian / Helvetian	?	Kamlial	Moghara	M		
20		M	Friasian								20
25		E	Santacrucian	Arikareean	Burdigalian / Aquitanian	Loh		Koru, Karungu / Namib	E		25
30	OLIGOCENE	L	Colhuehuapian	Whitneyan	Chattian	Hsanda Gol	?	?	L	OLIGOCENE	30
		M	?	Orellan	Rupelian	Houldjin			M		
35		E	Deseadan	Chadronian	Sannoisian	Ardyn Obo		Upper Fayûm	E		35
40	EOCENE	L	?	Duchesnean	Ludian	Shara Murun	Pondaung	Qasr-es-Sagha	L	EOCENE	40
45			Mustersan	Uintan	Bartonian	Irdin Manha		Birket-el-Qurun			45
50		M	?	Bridgerian	Lutetian	?	?		M		50
55		E	Casamayoran	Wasatchian	Cuisian / Sparnacian				E		55
60	PALEOCENE	L	Riochican	Clarkforkian	Thanetian	Gashato	?	?	L	PALEOCENE	60
65				Tiffanian							65
		M	?	Torrejonian					M		
70				Dragonian	(Montian ?)	?					70
		E	(Salamancan ?)	Puercan					E		
75	CRETACEOUS										75

+ E - early ; M - middle ; L - late — Age in Millions of Years — G.G. Simpson 1947

> Pliocene ≧ Oligocene, and that the ratio Eocene : Oligocene is on the order of 2 : 1.

The epochs have been divided into early, middle, and late subepochs. The three subepochs of each epoch are shown as equal in length, an arbitrary procedure. It is, however, likely that this is a fair, if rough, approximation, and there seems to be no acceptable way to reach a more probable arrangement. Even more approximate are the suggested durations of the various ages, formations, and local faunas. In the case of the local faunas, especially, the apparent suggestion of a duration for each must be taken as a purely conventional requirement of tabulation. It is, for instance, clear that the Gashato local fauna of Mongolia is all practically of one age and has no geologically perceptible duration, although it is necessary to allow it vertical space equivalent to about 5,000,000 years on the chart.

In the regional columns, distinction is made between provincial ages and stages, formations, and local faunas, units in quite different categories. The usage is that partly developed and partly endorsed by a Paleontological Society committee (Wood *et al.*, 1941). A provincial age is a time unit, smaller than an epoch, applicable throughout a given geological and faunal province, usually a continent. A provincial stage is the ensemble of all rocks (in this case, all continental sedimentary rocks) formed within a given provincial age. A formation is a rock unit, essentially a single mass of rock, defined by its distribution and lithology and not (or not only) by its age or fauna. A local fauna is a collection of fossils (in this case of fossil mammals) found within a limited area and stratigraphic range, and believed to represent animals that lived in association with each other. In the present chart, age and stage units are preferred and these, alone, are given when available.

The South American provincial ages and their approximate correlation are taken, with some slight modification, from a previous study by me (Simpson, 1940), which was a review and systematization of a large amount of earlier work by many hands. These South American provincial names apply, at present, to the Argentine as the only region on that continent with a good, described sequence of Tertiary continental strata and faunas. It remains to be seen whether the system can be more widely used, for instance in the as yet almost unpublished sequence found by Stirton (personal communication) in Colombia. If practicable at all, such wider use will doubtless require some modification of the system and perhaps will help to fill gaps in it.

The North American provincial ages are taken without modification and their correlation with European ages is taken with slight modification from the excellent report of a committee under the chairmanship of H. E. Wood, 2nd. (Wood *et al.*, 1941). The European provincial ages have long been established and are widely accepted and used, with considerable variation as to precise terminology and sequence. For a competent recent discussion of them, see Gignoux, 1943. There has been some attempt to extend this terminology throughout the Old World but this now seems premature and it may never become advisable. The provincial names are here taken as applying to Europe only, with occasional exceptions for immediately adjacent areas.

Asia cannot be considered as a single province for nomenclatural and correlational purposes and must be divided into (at least) two: Central Asia and China, on one hand, and India, Burma, and adjacent areas, on the other. There is no established system of provincial ages for either of these provinces, and this is not the place to propose such a system, even if the proposal would not be premature at this time. Representative local faunas are named within the central and eastern Asiatic province and recognized rock units (roughly formations) within the south Asiatic province. The central and eastern Asiatic local faunas, largely known from the work of Matthew and Granger, are summarized in Teilhard and Leroy (1942). The south Asiatic formations have been discussed, with ample reference to earlier work, especially that of Pilgrim, by Colbert (1935, 1938).

Tertiary mammals are as yet very poorly known in Africa. One or two local faunas are rich and important, but the record as a whole is spotty and scattered and does not now lend itself to useful systematization. There is no system of provincial ages and only a few local faunas can be designated.

The data in hand suggest that two different provincial sequences perhaps should be, or may eventually be, recognized, one for northern (more or less Mediterranean) Africa and one for central and southern Africa. I am not acquainted with any one adequate review of African Tertiary mammalian beds and faunas. Information on all the local faunas named on the chart may be found in or through Andrews (1906), Fourteau (1918), Hopwood (1929, 1933), and Stromer (1913, 1920, 1931).

The sequence of the columns on the chart has no significance other than the desire to bring together, as nearly as possible in two dimensions, the regions most often compared. For instance, although South America on one side and Africa on the other are brought against the epoch and subepoch designations, the placing of their ages and faunas on the epoch scale is far less reliable than for the North American and European ages. The basic relationship between epoch and age units should be sought on the North American scale. This shows, for example, that I here include the Duchesnean and what I believe to be its equivalents in the Eocene, not Oligocene, the Blancan and probable equivalents in the Pliocene, not Pleistocene, etc. That is, for present purposes the epochs are considered as defined in terms of the North American provincial ages. These definitions are, of course, disputed, but it is not proposed to discuss them here.

Finally, *it cannot be too strongly emphasized that two aspects of the chart are particularly and extremely unreliable:* the ages and durations in years, and the interprovincial correlations. These are very rough, very personal approximations. Certainly no other student will agree exactly with my judgment on these points, and I do not expect to hold to all my present opinions on them for long. The excuses for publishing such manifestly unreliable and subjective material are that some such arrangement has to be attempted as a background for broad studies and for future improvement, and that any arrangement sufficiently simple and clear for class and general use almost has to represent the opinion of a single student at a particular time. Such publication may, however, do more harm than good if its unreliable and ephemeral nature is not made clear to and firmly remembered by the reader.

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THE MOLLUSCAN GENERA OF BRUGUIÈRE

HENRY DODGE
Scarsdale, New York

ABSTRACT—Nomenclatural status of the molluscan generic names attributed to Bruguière is reviewed. Lists of valid names and of nomina nuda are given, with discussion of the evidence involved.

THE PURPOSE of these notes is to review the original sources of the generic names of Mollusks attributed to Bruguière, to list those which are nomina nuda, with the reasons for their invalidity, and to present a suggested although perhaps an incomplete list of those genera which may properly be credited to him. This involves a comment upon the equivocal position in which Bruguière has been placed by those not sufficiently familiar with the somewhat limited extent of his contribution to the Encyclopèdie Méthodique. Much of the error of which conchologists have been guilty in connection with the Bruguière names was undoubtedly caused by the slow and piecemeal publication of the text and plates of the great work which bears his name, by the fact that he left his work uncompleted and by his absence from France during the last six years of his life.

Jean-Guillaume Bruguière (called Bruguières by several biographers) was born in Montpellier, France in 1750. From the rather meagre biographical notes available it is possible to reconstruct only the barest outlines of the events of his life. We know that he took his degree in medicine in Montpellier but it is not recorded that he ever practiced his profession. His early adult life was devoted to botany but he soon turned his energies to the study of zoology. In 1773 he accompanied Kerguelen, in the role of zoologist, on the latter's second of the two famous voyages to the "mers australes," but his only known contribution to the results of the voyage was the discovery and description of a new reptile during his sojourn in Madagascar. Several commentators have stated that he wrote an account of this visit, possibly covering whatever invertebrates he noted there, but any such record appears to be lost. Moreover the official account of the two voyages (Kerguelen-Tremarec 1782) does not mention Bruguière.

On his return to Montpellier he played some part in the discovery of a coal deposit and this incident determined the whole course of his scientific life as he became so interested in the fossil invertebrates found in the workings that thenceforth he devoted all of his time to that branch of Zoology. In order to further his ambitions he soon went to Paris like every ambitious young scientist of his day. His first visit was in 1772. He appears again in Paris in1774 and by 1781 had made his home permanently in the capital and had become such a well-known figure there that his abilities engaged the attention of Daubenton who brought him to the notice of several of the most eminent French zoologists. He was the author of several papers on invertebrates in the first volume of the "Actes" of the Société d'Histoire Naturelle de Paris (1792) and in the first two, and only, volumes of the Journal d'Histoire Naturelle (1792) in such eminent company as Lamarck, Bosc, Olivier, Pelletier and Cuvier. In these short papers he wrote upon various topics relating to invertebrates and named and described several new species of mollusks but these writings contain no mention nor descriptions of new genera. The widespread public recognition of his growing ability soon became so great that he was commissioned to supply the treatise on Vermes for the Encyclopèdie Méthodique.

Of this treatise, which bears the separate title Histoire Naturelle des Vers, he completed only the first volume in his lifetime although it is probable that some of the plates of figures were finished or at least approved by him before his death. Volume 1 was published in two parts in 1789 and 1792 respectively, and took up in alphabetical order those genera of Vermes beginning with

Acarde and ending with Cone.[1] The work was continued and completed by Deshayes more than thirty years later by the publication of volumes 2 and 3 (1830–1832).

Volume 1 was preceded by an Index of genera (Tableau Systèmatique) covering the six orders of Vermes; Intestina, Infusoria, Mollusca, Echinodermata, Testacea and Zoophyta, arranged approximately, although with many changes, according to the Linnaean system. This Index, we must assume, lists all genera known to Bruguière at the time of its publication and was designed to serve as a complete table of contents not only for volume 1 but also for the remaining projected volumes of the work. It seems reasonable to assume that it was published in 1789 along with the first Part of the text volume although direct evidence of this fact is lacking. Each generic name in the Index is followed by a description which, although short, is sufficient under Article 25 of the International Rules of Zoological Nomenclature to support a valid genus if theretofore undescribed. This point will be more fully discussed later in this paper. There are thus two descriptions for many genera: that in the Index (1789) and, if the genus is further textually described in volume 1, the more detailed description in the text (1789 or 1792). Accordingly if a genus is described for the first time in either the Index or the text of volume 1 it may be cited as a valid Bruguière name. Moreover it is improper to cite a Bruguière generic name as of any other date than 1789 or 1792. The important thing to remember is that this single volume contains Bruguière's only published descriptions of invertebrate genera and therefore no invertebrate genus can be attributed to him which is not there described.

It is well to have in mind the publication dates of the various portions of the work:

TEXT

Vol. 1. By Bruguière. (Preceded by an Index of all genera in the six orders.)
Part 1. pp. 1–344, Acarde to Bulime (in part) 1789
Part 2. pp. 345–758, Bulime (concluded) through Cone 1792
(The two parts are ordinarily bound together with no title page or other line of demarcation between them, the joint volume bearing the date 1792.)

Vol. 2. By Deshayes. (This volume bears on its title page the names of Bruguière, Lamarck and Deshayes although Bruguière and Lamarck were both dead and, moreover, had no part in its preparation.)
Part 1. pp. i–vii, 1–256, Acame through Conchophora 1830
Part 2. pp. 1–144, Conélix to Foraminifères (in part) 1830
pp. 145–594, Foraminifères (concluded) through Mytulo-Pectinculus 1832
(The two parts are ordinarily bound together as in the case of volume 1, the title page bearing the date 1830.)

Vol. 3. By Deshayes. (All three names are on the title page as in Vol. 2.)
One part. pp. 595–1152, Nacelle through Zoomorphose 1832

It is important to note that the Deshayes volumes are not merely a continuation or completion of Bruguière's work but constitute a complete compilation of all genera *de novo*, including many genera which, although within the alphabetical scope of volume 1, were not known to or at least not listed by Bruguière. They also contain many articles on various taxonomic groups other than genera.

In the latter part of 1792, according to his biographers (but whether before or after the publication of volume 1 is uncertain), Bruguière, accompanied by his friend

[1] It is to be noted that the alphabetical sequence of genera is based upon the French forms of the names, so that there are certain names such as Char (*Gioenia*) and Arrosoir (*Penicillus*) which are described in the text portion of volume 1 although under their Latin names they would have been taken up later.

[2] For the dates of the publication of the Parts and their pagination I am indebted to the researches of Sherborn and Woodward as published in Zool. Soc. of London, Proc., 1893, pp 577–582, and 1899, pt. 2, p. 595, and in Ann. Mag. Nat. Hist., ser. 7, vol. 17, 1906, pp. 577–582. The sources of information consulted by these authors are listed in the last of the three papers cited.

PLATES

Pp. i–viii, 1– 83,	Plates	1– 29,	Vers	Infusoires	1791
	"	29– 61,	"	Intestines	
	"	61– 95,	"	Mollusques	
Pp. 85–132,	"	96–159,	"	Echinodermes	[1792]
	"	160–163,	"	Testacés (Loricata)	
	"	164–166,	"	" (Cirripedia)	
	Plate	167,	"	" (Teredo & Fistulana)	
	Plates	168–189,	"	" (Pelecypoda)	
	"	190–286,	"	" (Pelecypoda)	1797
	"	287–314,	"	"	[1798]
	"	315–390,	"	" (Gastropoda)	
	"	391–463,	"	"	
	Plate	464,	"	" (Heteropoda & Pteropoda)	1816
	Plates	465–471,	"	" (Gastropoda)	
	"	472–588,	Polypiers		

The dates in brackets are based upon external evidence. Plates 1–95 (1791) were published before Bruguière's departure from France in late 1792 and were probably supervised by him. He may possibly have been responsible for Plates 96–189 (1792?). The rest of the Plates were to have been approved by Lamarck and most of them probably were, although Bory de Saint Vincent, who succeeded to Lamarck's task, and possibly others, were responsible for some of them.

Olivier, left France on a voyage sponsored by the French Government to the countries of the Levant. This voyage upon which the two naturalists penetrated Asia as far as Bagdad and Teheran, lasted until 1798. Bruguière never returned to France alive. He died in Ancona, Italy, in 1798 almost immediately upon landing there on his way home. It would seem inescapable, considering the difficulty of communications between Europe and the Near East at the end of the eighteenth century, that he could have published nothing after he left France in 1792. We are therefore left with volume 1 of the Histoire Naturelle des Vers as the last conchological work published by Bruguière and the only one which contains any generic descriptions of mollusks.

The first part of the introductory pages of text in the Plate volumes were written by Bruguière. Pages 1–83 were certainly from his hand and possibly the whole Introduction up to page 133 was his work. The pages referred to, however, although they contain generic descriptions, cover only orders of Vermes other than Testacea and therefore their authorship does not concern us. The introductory pages after page 133 were probably written by others and in any case contain no descriptions of genera.

The date of Bruguière's death is often given as October 1, 1799, but was actually in 1798. This is proven by an irrefutable piece of external evidence: Lamarck, in the foreword to the "Prodrome" of 1799 which was read before the Institut National "le 21 frimaire an 7" (December 11, 1798) speaks of Bruguière as "my unfortunate friend who has just died at the conclusion of an important voyage."

The question of the identity of the person or persons who executed or supervised the execution of the plates is historically interesting but is not germane to the present discussion. What is important is that many of these plates, headed by names of genera which were not listed either in the Index nor in the text of volume 1 and which accordingly have never been described by Bruguière, have been repeatedly utilized as the basis upon which to rest his authorship of these genera. The blame does not lie at Bruguière's door. He never claimed them as his own. The blame rests upon those who, even since the publication of the Rules of Priority, have persisted in crediting these names to him. It is worthy of note that Deshayes, in the 1830–1832 volumes, was careful to say in each of these cases that Bruguière had never described the genus but had merely supplied the plates of figures. While Deshayes went rather thoroughly into the history of each generic name he cited he did not actually assign an author or date to any of them and it is impossible to say what his standard of authorship was. At least he recognized that Bruguière had not only not described the genera in question but had not

even identified his figured species. Deshayes himself was the first to assign specific names to many of these figures.

Lamarck, in the "Prodrome" of 1799, also correctly evaluated Bruguière's part in the creation of these genera saying (p. 66):

> Moreover it is seen from the figures which he left when he departed on his voyage and by the names which he gave them that although he had written nothing concerning the characteristics of the genera *houlette, lime, lucine, capse, cyclade, pandora* and *lingula* [Pedum, Lima, Lucina, Capsa, Cyclas, Pandora and Lingula] he had planned the erection [concu l'etablissement] of these genera.

Lamarck's comment quoted above proves that, at least in the case of the genera there listed, the plates had been prepared or approved by Bruguière before he left France. This involves plate No. 178 (published ?1792), plates Nos. 206, 231, 250 and 284–286 (published 1797) and plates Nos. 301–302 (published ?1798). This would seem to give some ground for concluding that all the plates up to No. 302 had been so prepared.

The following generic names which are often and indeed commonly attributed to Bruguière are thus nomina nuda under his authorship. I have excluded the brachiopods as their synonymy is sufficiently complicated to justify their treatment in a separate paper:

CORBULA Bruguière 1797. Not described by Bruguière. Figured on pl. 230, 1797. Nomen nudum.
Not *Corbula* 'Bolten' Roeding 1798 = *Asaphis* Modeer 1793 and not validly proposed by Roeding.[3]

CORBULA Lamarck 1799. First valid proposal. (That Lamarck intended to describe the same group as Bruguière's *Corbula* is shown by his reference to pl. 230).

LUCINA Bruguière 1797. Not described by Bruguière. Figured on pls. 284–286, and 277, 1797, as *Venus*. Nomen nudum.

LUCINA Lamarck 1799. First valid proposal. Chavan (1937, pp. 135–137) does not admit that *Lucina* Lamarck 1799 was validly proposed since Lamarck there attempted to designate a genotype which was inacceptable because (a) It did not accord with his diagnosis of *Lucina*, (b) because his "examples" are not to be considered as types, and (c) because no reference for or figure of the proposed type is supplied. No reason is perceived why the failure to designate a type should militate against Lamarck's otherwise valid proposal of the genus. No such requirement is set by Article 25 of the Rules for a genus erected before 1931. Chavan continues by saying that the first valid proposal of *Lucina* was in Lamarck's Système des Animaux sans vertèbres, 1801, where *L. jamaicensis* is given as "example" with adequate references. However, Opinion 79 holds that, "rigidly construed," the Système is not to be accepted as containing designations of type species. Therefore, if Chavan insists that a genus may only be validly proposed if a type is designated he cannot at the same time accept the 1801 proposal of the name. His opinion that the "example" of *Lucina* did not accord with the diagnosis of the genus in the Prodrome seems captious.

GALATEA Bruguière 1797. Not described by Bruguière. Figured on pl. 250, 1797. Nomen nudum.

GALATHEA Lamarck 1805. (Mus. hist. nat. Paris Ann., vol. 5, p. 451). *Pro Galatea* Bruguière 1797. Preoccupied by *Galathea* Fabricius 1793, Crustacean.

GALATEA Philippi 1850 (Abb. Conch. v. 3, p. 123). First valid proposal.

TRIDACNA Bruguière 1797. Not described by Bruguière. Figured on pls. 235–236, 1797. Nomen nudum.

TRIDACHNES 'Bolten' Roeding 1798. *Pro Tridacna* Bruguière 1797 but not validly proposed by Roeding.

TRIDACNA Lamarck 1799. First valid proposal. (Lamarck apparently considered Bruguière to be the author of *Tridacna* disregarding the lack of description. He said (1799, p. 66): "He erected the genera *Cardita* and *Tridacna*." In the face of Lamarck's words already quoted above as to Bruguière's "attempts" to create genera this comment on *Tridacna* must have been only an oversight).

PANDORA Bruguière 1797. Not described by Bruguière. Figured on pl. 250, 1797. Nomen nudum.

PANDORA Hwass (in) Chemnitz 1795. First valid proposal.

PEDUM Bruguière 1792. Not described by Bruguière. Figured on pl. 178 [1792]. Nomen nudum.

PEDUM Lamarck 1799. First valid proposal. Deshayes said (*op. cit.*, vol. 2, p. 284): " . . . it was definitely established by Lamarck in the Système des animaux sans vertèbres in 1801." It is not necessary to invoke the 1801 description as the same group had been adequately described in the Prodrome of 1799.

LIMA Bruguière 1797. Not described by Bruguière. Figured on pl. 206, 1797. Nomen nudum.

LIMA Cuvier 1798. First valid proposal. It is not necessary to establish that Cuvier's publication of *Lima* was earlier in 1798 than the publica-

[3] My acceptance of *Corbula* Lamarck 1799 as the valid name of the group included in Bruguière's *Corbula* involves adherence to the views expressed by Vokes (1945, p. 7) including his statement as to the unavailability of *Corbula* 'Bolten' Roeding 1798. The unavailability of all of the generic names in the Bolten Catalogue, except such as are monotypic or have a tautonymic type, follows as a matter of course.

tion of the Bolten Catalogue as the name was used only specifically in the latter work, as *Mantellum lima*.

CAPSA Bruguière 1797. Not described by Bruguière. Figured on pl. 231, 1797. Nomen nudum. (=*Asaphis* Modeer 1793).

CAPSA Humphrey 1797. Not valid under Opinion 51.

CAPSA Lamarck 1801. First valid proposal. (=*Asaphis* Modeer 1793).
Non Capsa Lamarck 1799. (=*Apolymetis* Salisbury 1929).
Non Capsa Lamarck 1818. (=*Iphigenia* Schumacher 1817).

AVICULA Bruguière 1792. Not validly described by Bruguière. Figured on pls. 177, [1792] and 198, 1797. Nomen nudum. Bruguière did not describe *Avicula* either in the Index to volume 1 or in the alphabetical arrangement of genera in the body of the text. It is "described" in the article "Conchyliologie" on page 536 of volume 1 where it is given as the first genus of "Diconchae figuratae" in the Heading "Methode de Klein." While the description there is characteristic it is merely a verbatim reprint (with the exception of one altered word) of the original description of Klein 1744, and being a mere republication of a pre-Linnaean description it does not serve to validate the original diagnosis as of the later date. *Vide* Opinions 21 and 57.

AVICULA Lamarck 1799. First valid proposal of the name but *Pteria* Scopoli 1777, of which it is an exact synonym, has priority.

CYCLAS Bruguière 1797. Not described by Bruguière. Figured on pls. 301–302 [1798]. Nomen nudum.

CYCLAS Lamarck 1799. First valid proposal of the name but *Sphaerium* Scopoli 1777, of which it is an exact synonym, has priority.

The following list contains those genera which may be properly attributed to Bruguière as having been described for the first time in volume 1 of the Histoire Naturelle des Vers, either in the Index or in the text:

TRIGONIA Bruguière 1789. Index, p. xiv, 1789. Figured on pls. 237–238, 1797.

CARDITA Bruguière 1792. Text vol. 1, p. 401 1792. (*Cardita* is not listed in the Index). Figured on pls. 232–234, 1797.

OLIVA Bruguière 1789. Index, p. xv, 1789. Figured on pls. 361–368, [1798]. Martyn's earlier use of the name, 1794, is not generally accepted as the Universal Conchologist is not consistently binomial and unless and until it is officially accepted or rejected it is preferable to credit the name to Bruguière.

Winckworth, in Mal. Soc. London Proc., vol. 18, p. 228, 1929, in discussing the availability of the Martyn names, says: "*Oliva*, by a happy chance, remains *Oliva*, Cuvier 1798, which has several months priority of *Porphyria*, Bolten, 1798." There would seem to be no necessity of raising, in the case of *Oliva*, the question of the priority of Cuvier's use of the name over that of the Bolten Catalogue since Bruguière's *Oliva* has a clear nine years priority over both.

CERITHIUM Bruguière 1789. Index, p. xv, 1789, and text, vol. 1, p. 467, 1792. Figured on pls. 442–443, 1816. *Cerithium* is credited by Bruguière to Adanson (pre-Linnaean). Although it is an exact synonym of *Clava* Martyn 1784 the latter name must be rejected for the same reason stated in the discussion under *Oliva*.

OVULA Bruguière 1789. Index, p. xv, 1789. Figured on pls. 357–358 [1798]. Not *Ovula* Heubner 1810.

FISSURELLA Bruguière 1789. Index, p. xiv, 1789. Not figured.

TEREBRA Bruguière 1789. Index, p. xv, 1789. Figured on pl. 402, 1816.

FUSUS Bruguière 1789. Index, p. xv, 1789. Figured on pls. 423–430, 1816. (=*Rostellaria* Lamarck 1799 and *Tibia* 'Bolten' Roeding 1798.)
Not *Fusus* 'Bolten' Roeding 1798 (=*Xancus* 'Bolten' Roeding 1798).
Not *Fusus* Lamarck 1799 (=*Fusinus* Rafinesque 1815).
Fusus Muller 1766 is non-binomial.
Antedated by *Fusus* Helbling 1779 (=*Cumia* Bivona 1838) which, however was not validly proposed.

CASSIDEA Bruguière 1789. Index, p. xv, 1789, and text vol. 1, p. 414. Not figured as *Cassidea*. The name *Cassidea* is not used in the plate volumes of the Histoire Naturelle des Vers. Plates 406–407, published in 1816, which give figures of the species included by Bruguière under his *Cassidea* 1789, was properly entitled *Cassis*, the priority of Scopoli's name having by that time been recognized.
Not *Cassidea* Link 1807.
Not *Cassidea* Swainson 1840 (=*Casmaria* H. & A. Adams 1853, in part and *Phalium* Link 1807, in part).
Antedated by *Cassis* Scopoli 1777.

FISTULANA Bruguière 1789. Index, p. xiii, 1789. Figured on pl. 167 [1792].

PURPURA Bruguière 1789. Index, p. xv, 1789. Figured on pls. 397–398, 1816. Genotype *Buccinum persicum* Linné, (by monotypy Lamarck 1799). *Buccinum persicum* Linné is given by Lamarck, in the Prodrome of 1799, as the "example" of the genus *Purpura*. The acceptance of these "examples" as genotypes has never been directly passed upon by the Commission on Zoological Nomenclature but the writer of the present paper is convinced that they should be. It is admitted that the Commission has handed down an opinion (Opinion 79) which might be considered as an inferential ruling against this view as it there held that "rigidly construed" Lamarck's 1801 work, the Système des Animaux sans Vertebres "is not to be accepted as designation of type species." I believe that the two cases are not parallel and that if the Commission should believe them to be and make the same ruling in the case of the Prodrome it would be in error. The dissent of Dautzenberg and Horvath to Opinion 79 seems to me to express the sounder

view. The reasons for my opinion are set forth in Nautilus, vol. 60, pp. 25–31, July 1946. If the Commission should rule that Lamarck's "examples" are inacceptable as genotypes then the first type designation for *Purpura* Bruguière 1789 would be that of de Montfort 1810 who also designated *B. persicum* as the type. Actually the name *Purpura* Bruguière 1789 has not yet been officially accepted as valid as the Com, mission has ruled in Opinion 74 that Apstein's 1915 list of *nomina conservanda* (including Bruguière's *Purpura*) could not be accepted *in toto* but that each of the generic names therein must be ruled on separately. If it should unfortunately be rejected the next available name would be *Haustrum* Perry 1811 with *Haustrum zealandicum* Perry as type.

PURPURA Lamarck 1799.
Not *Purpura* Martyn 1784.
Not *Purpura* 'Bolten' Roeding 1798.
Not *Purpura* Bruguière 1792, Jour. Hist. Nat. vol. 1, p. 29=*Typhis* de Montfort 1810, Genotype, *Purpura tubifer* Bruguière 1792 (by monotypy). *Purpura* Martyn 1784 is not only ineligible in any case (see note under *Oliva*, above) but is a homonym, being apparently equal to *Ceratostoma* Herrmannsen 1846. *Purpura* 'Bolten' Roeding 1798 =both *Purpura* Link 1807 and *Purpura* Schumacher 1817 (and probably *Phyllonotus* Swainson 1840).

PLACUNA Bruguière 1789. Index p. xiii, 1789. Figured on pls. 173–175 [1792].

PLACUNA Solander 1789. Nomen nudum, being undescribed.

PERNA Bruguière 1789. Index p. xiii, 1789. Figured on pls. 175–176 [1792].

PERNA Lamarck 1799.
Not *Perna* Retzius 1788, a Mytilid.

SILIQUARIA Bruguière 1789. Index p. xiii, 1789. Not figured.

ORTHOCERAS Bruguière 1789. Index p. xvi, 1789. Figured on pl. 465, 1816 as *Orthocera*.[4]

Because of the special and peculiar circumstances surrounding the Bruguière genera *Acardo*, *Gioenia* and *Penicillus* these names are not discussed here as they seem worthy of a more detailed treatment.

The claim for eligibility of the generic names in the above list (with the exception of *Cardita* and *Cerithium* whose attribution to Bruguière has never been questioned, apparently because of their lengthy descriptions in the text of volume 1) is based upon my conviction that the descriptions of genera contained in the Index or Introduction to volume 1 are sufficient, under Article 25 of the Rules and Opinion 1, to support valid genera whether or not these names are again described in the text of that volume or are tied to any species named therein. During the preparation of this paper my attention was called to an opinion by the Nomenclature Committee of the Malacological Society of London which places a limitation upon my views. This ruling is summarized in the Proceedings of the Society, vol. 26, p. 148 (1945) as follows:

> Bruguière 1789–1792. The generic names briefly diagnosed in the Introduction not accepted, unless species can be attributed to them in the text.

I can find no suggestion in the wording of Article 25 or in any other part of the Rules or Opinions which requires that a description, to comply with the law of priority, must be comprehensive or even fully characteristic of the genus described so long as it is understandable. It is, of course, admitted that a description, whether of a genus or a species, cannot be acceptable under the rule if it is not sufficiently lucid to indicate with certainty the group or species which it is intended to cover. The lack of clarity in many of Linnaeus' specific descriptions, for example, makes it impossible to determine what he intended to describe, and therefore these must rank among the "lost" species. I submit that while some of Bruguière's generic descriptions contained in the Index of the work under discussion are so faulty as to make them inacceptable for this reason, nevertheless the diagnoses of those genera listed in this paper as valid Bruguière names are not subject to this criticism. These latter at least, although short, are adequately characteristic and leave no doubt in one's mind as to the groups which the author was describing.

It is instructive in this connection to compare them with Lamarck's diagnoses of the same genera in the Prodrome of 1799. With the possible exception of *Fissurella* and *Fusus* they follow very closely the Bruguière Index descriptions. Indeed most of them use language so close to that of Brugruère as to be practically identical or at least close paraphrases of the latter's language. It is abundantly evident that

[4] Lamarck's *Orthocera* as described in the Prodrome, 1799, is undoubtedly an emendation of the name *Orthoceras*, as it appears from Lamarck's description to cover the same group. It is to be noted that plate 465 was not published until 1816 by which time Lamarck's emendation had been made.

Lamarck based his Prodrome descriptions upon those of Bruguière as in most of them the change involves only a word or two. It has never been suggested that the Prodrome descriptions are not acceptable or that their brevity militated against their use or that they were not sufficiently lucid. I suggest that this comparison should dispose of the argument that the Bruguière diagnoses are inacceptable because of brevity or a failure to mention certain generic traits.

It is not necessary to labor this point, however, or to rely entirely upon the comparison of Bruguière's Index descriptions with those in Lamarck's Prodrome as the International Commission of Zoological Nomenclature has already clearly indicated its attitude on the question. The background as well as the text of Opinion 126 affords a very close parallel to the present case. The Commission was there asked to declare that the specific names in Orbigny's Prodrome de Paleontologie Stratigraphique Universelle (Paris 1850) should be considered to be nomina nuda "unless accompanied by a figure or description published by an earlier author." The arguments for the protagonists for this view were predicated upon the fact that each of the Orbigny descriptions "rarely occupies more than two lines and is quite inadequate as a specific diagnosis."

The Commission did not accept this view but ruled that there were no grounds for treating the Prodrome differently from other works containing preliminary diagnoses and that they did not see their way clear to declare the new names in that work as unavailable or as nomina nuda under the Rules. It was intimated in the course of the discussion that some of the Orbigny definitions might be so brief as to be unavailable but the Opinion does not condemn the whole work for that reason. The individual description should be considered upon its own merits. The Opinion adds: "In all such cases the decision whether a diagnosis is adequate or no must be made by a systematist and not by the Commission." Indeed the heading of the Summary of Opinion specifically states that the Orbigny names are to be "nomenclatorily available."

The Opinion gives support to the views here expressed. It certainly does not justify the sweeping statement of the London Committee. There may be in Bruguière's work, as in Orbigny's Prodrome, names so briefly and uncharacteristically described as to justify a declaration of their invalidity but I submit that none of the names here listed fall into that class.

I am not prepared to admit that the word "description" in Article 25 means "a long and amply characteristic description." But even if that meaning should be adopted the words "indication" and "definition" in the same Article are certainly words of a less narrow meaning and were, I contend, obviously intended to protect the eligibility of diagnoses which were sufficiently lucid although brief. In the case of the word "indication" this has been settled by the Commission's language in Opinion 1, which is clearly an attempt to uphold many names which would fall if the word were given too narrow a meaning. The other two words have not been specifically passed upon but when they are I believe that the Commission's action will be similarly broadening.

Nor can I find any justification in the Rules or Opinions for the limitation placed upon Article 25 to the effect that a description must be referable to a species in the text in order to be acceptable. Certainly Opinion 46 covering genera without mention of species does not stand in the way. Not only is that Opinion wholly concerned with the designation of types and not with the eligibility of the generic name itself but by its very language it permits the assumption that the failure to name species is not *per se* a failure which invalidates the generic name. Indeed the limitation placed upon Article 25 by the Nomenclature Committee seems to be phrased in a manner which is self-destroying. If there are species mentioned in the Text to which the Index descriptions are referable then the existence of the Text descriptions render it unnecessary to invoke the Index descriptions.

I realize that when the law of priority was enacted the particular problem here discussed was not contemplated. Indeed many situations have arisen since then which are not covered by the language of the law and in which any attempt to graft summary interpretations upon it would work a hardship or produce decisions which go beyond the plain wording of the law. Article 25 does

not, for example, satisfactorily settle the question of "manuscript names," as the manner in which we customarily attempt to give credit to the earlier author who did *not* publish is a clear violation of the text of the law, invoked because of our unwillingness to place a hardship upon him. It is an attempt to summarily amend the law. Nor is Article 25 sufficiently clear as to the meaning of the word "published." Witness the controversy, not yet adequately resolved, as to the status of the Museum Boltenianum. If the Article does not cover these cases which have arisen to plague us would it not be better to officially amend it by amplifying its meaning?

It is axiomatic in the law by which the conduct of people is governed that words cannot be read into a statute to make it fit the particular facts before the court. Interpretation of a statute is, of course, permissible but interpretation must not be abused, must be used sparingly and must in all cases be limited to deciding what was the plain intent of the lawmakers. A statute once enacted must not be whittled down or built up to fit cases which its words do not cover and which were plainly not contemplated by the enacting body. The only alternatives in such a case are to amend the statute or to fill the lawbooks with summary decisions which violate the Law. Article 25 and Opinion 1 represent the law for zoologists and the same alternatives are presented to them. As long as the law is in effect there is no justification for court-made amendments as a substitute for action by the Commission which is our lawmaking body.

We are thus dealing with a duly enacted law and there should be no difference in interpretive treatment as between one code of laws and another. The same punctiliousness and the same respect for the written law should govern us if we are not to condone a cumulative patching-up of the code which we have adopted.

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PALEONTOLOGICAL NOTES

PLICIRHYNCHIA, A NEW GENUS OF TERTIARY BRACHIOPODA FROM PATAGONIA

R. S. ALLAN
Canterbury University College, Christchurch, New Zealand

ABSTRACT—*Plicirhynchia* gen. nov. is proposed for the Patagonian Tertiary species *Rhynchonella plicigera* von Ihering, 1897.

In his final summary of the affinities of austral Recent and Tertiary brachiopods J. A. Thomson (1927, p. 153) referred *Rhynchonella plicigera* von Ihering to the genus *Tegulorhynchia* Chapman and Crespin, 1923 (type: *Rhynchonella squamosa* Hutton, 1873) Patagonian material has been available at the United States National Museum, to the authorities of which institution I am grateful for facilities for study. The Patagonian fossil does not agree in all respects with the genotype of *Tegulorhynchia*, and is made the type of a new genus.

PLICIRHYNCHIA Allan, n. gen.

Genotype: *Rhynchonella plicigera* von Ihering, 1897.

Diagnosis.—Shell subpentagonal, hinge line curved, uniplicate, test impunctate, capillate with costae developing at about half the length, growth lines inconspicuous, hence costae not imbricate or spinous. Beak rather long, acute, suberect, foramen rather small, incipiently submesothyrid, deltidial plates conjunct, passing down ventrally into a fairly long pedicle-collar. Hinge teeth strong, supported by dental plates which are recessive ventrally. Dorsal interior as in *Tegulorhynchia*.

PLICIRHYNCHIA PLICIGERA
(H. von Ihering, 1897)

1897. *Rhynchonella plicigera* VON IHERING, Rev. Museu Paulista, vol. 2, pp. 270–271, text-fig. 7 on27 p. 0.
1902. *Rhynchonella plicigera* von Ihering, ORTMANN, Repts. Princeton Exp. 4, Palaeont., pt. 2, pp. 70–72, pl. 12, figs. 3a–d.
1903. *Rhynchonella plicigera* VON IHERING, Mus. Nac. Buenos Aires Anal., ser. 3a, tom. 2, p. 334, n. f.
1907. *Rhynchonella plicigera* VON IHERING, *idem*, ser. 3, tom. 7, p. 481, n. f.
1910. *Hemithyris plicigera* (von Ihering), BUCKMAN, Wissensch. Ergebn. Schwed. Südpolar-Exp. 1901–1903, Bd. 3, Lief 7, p. 12, pl. 1, fig. 10.—Glauconitic Bank, Cockburn Island, Antarctica.
1914. *Rhynchonella plicigera* VON IHERING, Notas Prelim. do Museu Paulista, I (3), pp. 11–12, n. f.
1927. [*Tegulorhynchia*] *plicigera* (von Ihering), THOMSON, New Zealand Board Sci. and Art, Man., no. 7, p. 153, n. f.—name only.

FIG. 1—*Plicirhynchia plicigera* (von Ihering). U. S. Nat. Museum specimen from Mazaredo, Patagonia, ×2.

Type locality.—Golfo de S. Jorge (Lower Patagonia). Type in the von Ihering Collection, Museu Paulista.

Remarks.—Both von Ihering (1897) and Ortmann (1902, p. 71) compared this Lower Patagonian rhynchonellid with *Tegulorhynchia nigricans* (Sowerby) from New Zealand. I agree with von Ihering that his species differs in the three characters noted by him, viz. (1) in the more triangular and less transverse shape; (2) in the narrower beak; and (3) in the smaller foramen. Ortmann concluded that "The only difference of our

fossil Patagonian form from the New Zealandian is the tendency of the plaits [i. e. costae] to disappear toward the umbo of both valves" (1902, p. 71).

More important is the fact that *T. nigricans* (Sowerby) and other species of *Tegulorhynchia*, including the genotype, are multicostate with the costae developing directly on a smooth stage. In *Rhynchonella plicigera* von Ihering the multicostation develops at about half the length on a finely capillate shell. The capillae are more prominent before multicostation commences but extend to the anterior margin. In *T. nigricans* also fine, close-spaced lamellae are a conspicuous feature of the ornamentation; the Patagonian fossil shows this hardly at all. Capillate ornamentation is unknown in *Tegulorhynchia* and its presence in *R. plicigera* means that that species cannot be included in *Tegulorhynchia* which therefore, does not occur in the Tertiary beds of Patagonia.

However Thomson (1927, p. 153) included *Hemithyris imbricata* Buckman (1910, p. 11, pl. 1, fig. 12) from Cockburn Island, off Graham Land, Antarctica, in *Tegulorhynchia*. This species was founded on one imperfect ventral valve which Buckman reported "appears to possess no dental plates," which are present in both *Plicirhynchia* and *Tegulorhynchia*. The imbricate multicostation of *H. imbricata*, and the general appearance are suggestive of *Tegulorhynchia* but the species is obviously in need of restudy.

This is the second rhynchonellid from Tertiary strata in Patagonia to be compared with species of *Tegulorhynchia* from New Zealand. The first was *Rhynchonella patagonica* von Ihering, 1903 which the writer (Allan, 1938) made the type of a new genus *Patagorhynchia*. In both cases study of actual specimens has failed to substantiate the supposed relationship, and has led to the recognition and separation of homoeomorphous genera.

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CORRIGENDA FOR "INDEX FOSSILS OF NORTH AMERICA"

ROBERT R. SHROCK
Massachusetts Institute of Technology, Cambridge, Massachusetts

The publishers of INDEX FOSSILS OF NORTH AMERICA by Hervey W. Shimer and Robert R. Shrock have requested us to submit to them such corrections as can be made without undue cost in a proposed reprinting. Listed below are all the significant corrections in the first printing which thus far have come to our attention. Items which could not be included in the reprinting are indicated by an asterisk preceding the page number. Reprints of this list may be obtained from the above address.

Our appreciative thanks are due the several paleontologists who have called our attention to errors and omissions in the book. It is hoped that in the future other faults which are discovered will be reported to us so that from time to time we can publish additional corrigenda.

Page and Column		*Line*	*Comments*
*vi		6, down	After the word ways, insert: Mimeographed lists of index fossils compiled and sent to us by E. R. Cumings, G. Marshall Kay, G. O. Raasch, C. R. Stauffer, and W. H. Twenhofel were useful in several ways.
70L		3, up	for (Hall) read Elles
*164	pl. 61		for lg read ld for ld read 2c
317L		3, up	for **M.** read **M. Ord.—**
361		3, down,	in pl. 142 caption: for **ovalis** read **perovalis**
364L		10, down	for *ovalis* read *perovalis*
		14, down	for **ovalis** read **perovalis**
367L		5, down,	in footnote: for R. I. Imlay read R. W. Imlay for C. C. Kindle read C. H. Kindle
367R		15, down,	in footnote: for R. I. Imlay read R. W. Imlay
*416	pl. 166		Fig. 15 is missing; it can be found in Kans. Geol. Surv. 6, pl. 22, fig. 10.
448	pl. 182		to figure in lower righthand corner add number 39
449		2, up,	in pl. 182 caption: for **38. T.** read **38, 39. T.**
451R		12, down	for 38 read 38, 39
495		4, down,	in pl. 204 caption, correct line to read: **torta** [Ac N Sc Phila, Pr 78]. **14, 15. Pterocerella poinsettiformis** [**14.** Pal N J 4. **15.** U Tex Pub 4101; print furnished In explanation of this correction it should be pointed out that figs. 14 and 15 of plate 204 are of the same specimen, not two species as indicated, and represent *Pterocerella poinsettiformis*. Dr. L. W. Stephenson, who is the authority for the above statement, replied as follows to our query concerning the similarity of the two figures: "The two figures pertain to the same specimen. Dr. Weller applied the name of the Mississippi species *Pterocerella tippana* (Conrad) to an indeterminate internal mold from New Jersey, and used a Texas specimen to illustrate it. I considered the Texas species different from the Mississippi one and gave it (the Texas one) the name *Pterocerella poinsettiformis*. The latter, in my opinion, is the correct name of the figured specimen. (See Texas Univ. Pub. 4101, p. 309, pl. 58, figs. 9–12, 1941.)"
499R		4, down	delete: (**204**—14)
		7, down	delete: N. J. (Matawan);
		8, down	delete: ; Tex. (Navarro).
		9, down	for 15 read 14, 15
*552	pl. 228		Figs. 21–24 are of the genotype material of *Allumettoceras*, hence are incorrectly labelled on p. 553 as *Tripteroceras hastatum*. This error, called to our attention by Dr. Edward Leith, deserves special notice and we take the liberty of quoting his comments (personal correspondence, August 6, 1945): "On plate 228 figures 21, 22, 23 and 24 are described as *Tripteroceras hastatum* as given in DUB JSL 20. That is correct for that plate description in DUB 20 but the plate legend for Foerste's plate XXXI of DUB 20 which lists figures 2A–D (these correspond to the figures 21–24 on your plate 228) is apparently in error. Foerste in the DUB JSL for 1926 proposed the new genus *Allumettoceras* on page 311, stating: 'Genotype: *T. pauquettense* Foerste, Bull. Denison Univ., vol. 20, 1924, p. 233, pl. 31, figs. 2A–D (not figures 3A–D which illustrate *T. hastatum* Billings).' On the same page he also reviews *Tripteroceras* Hyatt and states: 'Genotype: *Orthoceras hastatum* Billings . . . . . plate 31, figures 3A–D (not figs. 2A–D which illustrate *Allumettoceras pauquettense* Foerste).' "It thus appears that on plate 31 of DUB 20 the names were misplaced on the legend but correct in the text for Foerste in DUB 27, Dec. 1932, part 1, on page 131, states that the names of the two species *hastatum* and *pauquettense* were interchanged in the description of the plate (that is 31 of DUB 20) but were given correctly in the text. Thus on your plate 228 the illustrations given for *T. hastatum*, the genotype species of *Tripteroceras*, have the genotype material of *Allumettoceras*. This certainly might lead to errors especially since *Allumettoceras* has a nummuloidal siphuncle, *Tripteroceras* has a cylindrical siphuncle, and your figure 22 on plate 228, which is labelled as *T. hastatum*, has a nummuloidal siphuncle and is really *Allumettoceras*."

Page and Column		*Line*	*Comments*
*553		7, down,	in pl. 228 caption, correct last part to read: **21–24. Allumettoceras pauquettense** [DUB
*557L		14, down	for *paquettense* read *pauquettense*
*557L		19a, down,	insert: ***A. pauquettense** (Foerste) (**228**—21–24). **Black River—Trenton:** Ont. (Leray).
*557L		31, 32, down	delete (they now read): ***T. hastatum** (Billings) **228**—21–24). **Black River—Trenton:** Ont. (Leray).
580	pl. 242		to figure in lower righthand corner add the number 20
581		2, up,	in pl. 242 caption: for **18, 19.** read **18–20.**
587L		34, down,	for **M.** read **N.**; for 18, 19 read 18–20
*626	pl. 264		The facial sutures of *Cedaria woosteri* are incorrectly drawn on fig. 8 of plate 264 according to Dr. Christina Lochman who has advised us that Dr. G. O. Raasch has determined the true nature of the sutures to be quite different from those shown on our figure. It is hoped that Dr. Raasch will publish a revised figure in the near future.
*630	pl. 266		The cranidium assigned to *Uncaspis*, and illustrated in fig. 25 of plate 266 as *U. unca*, was recently made the holotype of *Modocia walcotti* by Lochman (Jour. Paleontology 17: 233, figs. 1 and 2, pl. 35, 1943).
*701L		lines 36 and 37,	as shown below, should be deleted because *S. rugosa* is equivalent to *Helcionella subrugosa*, as indicated on p. 439, L column, lines 22 and 23. Delete: **S. rugosa** (Hall) (**297**—9–14). **Camb.:** Newf.; Labrador; Que.; N. Y.
*703		4, down,	in pl. 297 caption: for **Stenotheca rugosa** read **Helcionella subrugosa**
717L		13, down	for 37 read 39
719R		27, down	for 39 read 37
719			correct last six lines of pl. 303 caption to read: section of a colony (×0.25); natural section of a compound colony whose total width is about 1.3 m (50 in.) (×0.5). **35, 36. Cryptozoon undulatum** (×0.45) [Am Mid Nat 18]. Transverse section through a series of domes of several sizes; vertical section through hypotype showing internal structure. **37. Climactichnites wilsoni** [SMC 57 (9)]. A portion of a slab much reduced (×0.02), showing several trails. **38. Protichnites logananus** [SMC 57 (9)]. A slab 145 cm×87.7 cm (4 ft 10 in.×2 ft 11 in.), reduced to about ×0.06, showing several trails. **39. Cryptozoon proliferum** (×0.5) [Md G S, Camb-Ord]. Upper side of a well preserved specimen, the original of which was 55 cm (22 in.) wide. The specimen shows several colonies (heads) unequally developed.
*723L		34a, down,	insert: pauquettense, 557, 228—21–24
735L		10, down	for 39 read 37
737R		20, up	for 37 read 39
751R		3, down	add: 297—9–14
763L		4, down	for 18, 19 read 18–20
773L		14, down	for ovalis read perovalis
774R		22, up	for 15 read 14, 15
774R		21, up	delete: tippana, 499, 204—14
*780R		20, down	delete: rugosa, 701, 297—9–14
*785L		39, down	delete: hastatum, 557, 228—21–24
*785L		40, down	for paquettense read pauquettense
785R		2, down	for 38 read 38, 39
794R		5, up	for 38 read 38, 39
*809L		34, down	delete: Tripteroceras, 557, 228—21–24
819R		33, down	delete: Prionothyris, 364, 142–16–19
*820L		35, down	for paquettensis, e read pa(u)quettensis, e
*820L		35a, down	insert: Allumettoceras, 557, 228—21–24
821L		45a, down	insert: perovalis, Prionothyris, 364, 142—16–19
822L		20, up	for 15 read 14, 15
823L		25, down	for 37 read 39
825R		13, up	for 18, 19 read 18—20
*826L		45, down	delete: Stenotheca, 701, 297—9–14
*830R		32, down	add: 297—9–14
832R		13, down	delete: Pterocerella, 499, 204—14
836R		10, up	for 39 read 37

The interested reader will find additional comments on INDEX FOSSILS in the following reviews:
1944, Science, n. ser. vol. 100, pp. 125–126. (P. E. Raymond).
1945, Am. Assoc. Petroleum Geologists Bull., vol. 28, pp. 1220–24. (C. E. Decker).
1945, Am. Jour. Sci., vol. 243, pp. 166–168. (C. O. Dunbar).
1945, Jour. Geology, vol. 53, pp. 140–142. (W. H. Easton).
1945, Jour. Paleontology, vol. 19, pp. 412–414. (J. M. Weller).

HARAMIYA, NEW NAME, REPLACING *MICROCLEPTES* SIMPSON, 1928

GEORGE GAYLORD SIMPSON
American Museum of Natural History and Columbia University, New York

Mr. Robert G. Chaffee has kindly called my attention to the fact that *Microcleptes* Simpson, 1928 (Cat. Mesozoic Mammals in . . . the British Museum, p. 55) is preoccupied in Coleoptera by *Microcleptes* Newman, 1840 (Entomologist, vol. 1, p. 11). The new name *Haramiya*[1] is hereby proposed to replace *Microcleptes* Simpson *nec* Newman, type *Microlestes moorei* Owen, 1871, the name of which now becomes *Haramiya moorei* (Owen). *Microcleptes fissurae* Simpson, 1928, is referred to this genus and now becomes *Haramiya fissurae* (Simpson).

The family names Microlestidae Murray, 1866, and Microcleptidae Simpson, 1928, both based on preoccupied generic names, are now replaced by Haramiyidae, new name. The Haramiyidae figure in the literature either as Triassic mammals (*incertae sedis* or Multituberculata) or as theriodont reptiles. They may be either or neither.

[1] Arabic, "trickster, petty thief," similar in meaning to *Microcleptes*. Use of roots other than Latin and Greek is authorized by the International Rules, has sufficient precedent, and become almost a compulsion as it becomes increasingly likely that a descriptive name of Latin or Greek origin will be obscurely preoccupied. *Haramiya* is feminine in gender and the accent is on the second syllable.

THE GENOTYPES OF *CANCELLOTHYRIS* THOMSON, 1927, AND *COPTOTHYRIS* JACKSON, 1918

R. S. ALLAN
Canterbury University College, Christchurch, New Zealand

Cancellothyris Thomson was proposed in 1926 (Ann. Mag. Nat. Hist., ser. 9, vol. 18, 1926, p. 525) for the Recent Australian brachiopod *Terebratula cancellata* Küster (Conch. Cab., ed. 2, vol. 7, 1843, p. 35). This combination had been previously used by Eichwald (Zool. spec., I, 1829, p. 276). In his "Brachiopod Morphology and Genera (Recent and Tertiary)" (New Zealand Board Sci. and Art, Man. no. 7, 1927, pp. 2, 18, 76 and 188) Thompson proposed *Cancellothyris australis* nom. nov. for Küster's species. Unfortunately earlier in the same year H. J. Finlay (Trans. New Zealand Inst., 57 (March 10) p. 533), noting that Küster's name was preoccupied, provided *Terebratulina hedleyi* nom. nov. as a substitute. That Finlay's emendation has priority is clear from the fact that in another connection Thomson (1927, p. 156) referred to Finlay's paper. The genotype of *Cancellothyris*, therefore, takes the name *Cancellothyris hedleyi* (Finlay, 1927).

Coptothyris Jackson (Geol. Mag., dec. 6, vol. 5, no. 10 (Oct.) 1918, pp. 479–480) was substituted for *Thomsonia* Jackson (*idem*, dec. 6, vol. 3, no. 1 (Jan.) 1916, p. 22) when it was found that the latter had been used by Signoret in 1879 in the Insecta. The genotype of *Thomsonia* Jackson, and there-

fore, of *Coptothyris*, is *Terebratula grayii* Davidson (Zool. Soc. London Proc., pt. 20, 1852, p. 76), a Recent Japanese species. Unfortunately Davidson had earlier used the same name for a Silurian brachiopod (*Terebratula grayii* Davidson, Soc. Géol. France Bull., sér. 2, vol. 5, 1848, p. 331) which is the genotype of *Streptis* Davidson (Geol. Mag. dec. 2, vol. 8, 1881, p. 150). Consequently it is necessary to find a substitute name for *Terebratula grayii* Davidson, 1852. In this connection it must be noted that in 1871 Davidson described two species of Japanese brachiopods, viz. *Magasella adamsi* (Zool. Soc. London Proc., 1871, p. 307, pl. 30, figs. 23–24) and *Magasella gouldi* (*idem*, p. 307, pl. 31, figs. 11a–c) which Thomson (op. cit. supra, 1927, p. 268) regarded as immature stages of *Coptothyris grayii* (Davidson). There is some doubt about *Magasella gouldi*, which, as Dall has noted (U. S. Nat. Mus. Proc., 57, 1920, p. 344), may be an immature stage of a *Terebratalia*. However, *Magasella adamsi* Davidson, described first on the same page, and definitely ascribed to *Coptothyris grayi* by Thomson, appears to be available for *Terebratula grayii* Davidson, 1852, not of Davidson, 1848. The name of the genotype, therefore, should read *Coptothyris adamsi* (Davidson, 1871).

EXTENDED REMARKS ON RELATIONSHIPS OF MARINE ANIMALS TO SALINITY

GORDON GUNTER
Marine Laboratory, The University of Miami, Coral Gables, Florida

Sinclair (1947) has raised some question concerning what he considers undue emphasis upon the importance of salinity gradients and faunal distributions to paleontology as set forth in my recent brief note (Gunter, 1947). He states that probably in seeking brevity and simplicity I gave the wrong impression. Possibly this criticism is correct, as shown by the fact that a large part of Sinclair's statements, suggesting that salinity gradients are not of great importance in marine areas, apply to the open ocean where salinity gradients of magnitude great enough to influence faunal distributions do not exist.

It should be stated that the conditions where sizes of animals and species change in correspondence with a salinity gradient are where the gradient is from fresh water to sea water, or zero to 35.0 parts per thousand saline. Such areas are estuarine and the gradient usually extends over a relatively short distance in miles, although in some instances it may be a few hundred miles, *vide infra*. It was specifically stated in one place in my paper (Gunter, *op. cit.*) that the principles set forth applied to a salinity gradient "from the river mouths to the open seas . . . " and along the coasts. Such areas are estuarine and the statements were thought to be sufficiently clear.

Sinclair says that "situations where pronounced disparities in salinity exist are very rare . . . ." That is true except in certain coastal and shallow sea or bay areas, some of which cover hundreds or thousands of square miles. These marginal areas of the seas should, it seems, be of particular interest to geologists, but as a zoologist I cannot presume to expound upon their geological importance. Today such areas are faunistically very important. Many abundant marine animals must have bay or estuarine conditions and some of our important fisheries depend on such species, viz, the oyster, the blue crab, shrimp and many fishes.

Sinclair's statement: "If the variety of species and the size of individuals increases, then the simple, and obvious interpretation is that one is approaching shore," is erroneous except in very specialized cases. In any estuarine or shallow sea area such a condition means that one is leaving the shore and going towards the open sea. It is the general rule in the sea that smaller motile animals approach the shore and raise in the shallows, moving outward to deeper water as they become larger. Many small fishes and other animals are found in bays, where their larger congeners are never seen. Specific

evidence for this (Gunter, 1945) is based on thousands of total length measurements. General observations on all coasts verify it. This fact can not be contravened by a bare statement to the contrary. Furthermore, there is strong evidence that the majority of marine fishes, which invade fresh water are smaller specimens (Gunter, in press) and I have shown that in rivers that small shrimp (*Macrobrachium*) stay closer to shore than their elders. Of course if we leave the somewhat pauperate fauna of the high seas and approach the shore over the continental shelf the number of species will increase. That the average size within a species will increase is doubtful and has never been demonstrated.

Sinclair seems to think that temperature gradients should be more important to paleontologists than salinity gradients. Temperature gradients within estuarine and shallow sea areas are not great and their direction becomes reversed in winter, so that the deeper water becomes warmer. Temperature is important in connection with seasonal cycles of all kinds, but the gradients are small, transitory or reversible and are not factors on which paleontologists can get dependable information or base deductions, so far as the local area of a bay or shallow sea is concerned.

Over a climatic range or as we approach the tropics from the pole there is a gradient, with corresponding faunistic changes as Sinclair has outlined. These are well known facts of marine zoogeography and necessitate no further discussion here. The zoogeographic temperature gradients are at right angles to the salinity gradients of the marginal areas of the seas and in contrast to them extend over hundreds of miles. So far as these gradients on a marine geological horizon go they are very gradual and changes would be hard or impossible to detect within a range of a few hundred miles. For that reason they are not as valuable as salinity gradients, nor do they apply to the same areas. They are therefore quite different from the easily detectable effects of salinity gradients of shallow seas, which are only a few miles in extent. There are, of course, some places where sharp changes in temperature take place, but these are essentially breaks and not gradients.

My observations on salinity gradients and their effects on faunistic distribution in shallow water, were made independently as the result of several years of observation and thousands of measurements of marine animals. Most of the proof was given in Gunter (1945 and in press). The phenomenon has been observed in part by some previous workers, cited in Gunter (1947) and has received some attention from zoogeographers. Hesse, Allee and Schmidt (1937) discuss the Baltic Sea which presents a distinct salinity gradient from its mouth to head of the Gulf of Bothnia and state, p. 283, "The number of species of marine animals decreases regularly from the west toward the east . . . ." They also say, p. 25, that the number of species is regularly decreased along a falling salinity gradient by continued selection of euryhalin forms. It has been my observation that this faunal characteristic is always present and detectable over a falling salinity gradient. It is a general rule applying to all such areas of the earth. In effect it is merely the existence of a special type of zonation not only of species but to some extent of the sizes within a species, such as is found on beaches. The phenomenon is always present, is easily detectable and its importance in shallow coastal marine areas has not been overemphasized. Furthermore, it is not easily confused with a temperature gradient. Temperature gradients are much less clear cut in shallow seas, although they also exist locally and in coastal areas with varying salinity, they are blanketed over by salinity gradients so far as faunal effects are concerned. Ecologically the chief detectable influence of temperature is in governing seasonal cycles, while that of salinity is in establishing faunal gradients or zonation.

The relative importance of salinity and temperature in estuarine areas is difficult to assay. It seems, however, that most estuarine animals will tolerate considerable, but different, ranges of salinity. Within the salinity range tolerated temperature usually has sharper and more easily detectable effects. My studies in bays and estuarine areas have not overemphasized salinity over temperature as an ecological factor. In Gunter (1945, p. 102) the following statement was made:

> It appears that the temperature cycle is chiefly

responsible for the seasonal movements and other recurrent cyclic activities of the fishes under discussion. The temperature cycle is definite while the general salinity changes are not nearly so regular. The winter and spring in general are the times of greatest rainfall but this is not always the case. A salinity gradient from a very high to very low salinity is more or less maintained at all seasons and a migratory animal could presumably take its choice so far as salinity of the environment is concerned. Such a wide temperature gradient is on the other hand not present at any given season in the shallow Gulf waters. In a few instances there are indications that either temperature or salinity is clearly more operative than the other factor in influencing the movements or presence of a species in a given environment at a given time, but mass movements coincide with the temperature cycle. Both of these important physical factors, salinity and temperature, have definite limiting and differential effects, which are difficult to separate merely by observation. Nevertheless, it appears that temperature is the chief factor affecting and initiating seasonal migrations and other seasonal cyclic actions of the fishes of this coast.

Nevertheless, temperature gradients do not have detectable faunistic gradients in shallow water marine areas regularly in correspondence with them, which could be detected by paleontologists, chiefly because temperatures change quickly and animals are sensitive to such changes and because the gradients in the same area are often reversed in direction during the year.

I think Sinclair's (*op. cit.*) objections arise from (1) the fact that my statements were taken to apply to all the seas, whereas they hold only for certain marginal areas of the seas with a sharp salinity gradient, and (2) lack of acquaintance of the regularity, without exception, with which faunistic gradients or zonations correspond with salinity gradients in coastal seas. Proof of this latter point can be found in the papers cited in this and my preceding note. My ecological studies of marine animals have all been chiefly concerned with the effects of two factors, salinity and temperature. The value of known salinity effects to paleontology was given (Gunter, 1947). On the other hand I am now prepared to make comparable general assertions concerning known effects of temperature on modern marine animals, which might be valuable to paleontologists, except the one concerning climatic temperature gradients, *vide* Sinclair (*op. cit.*), the value of which is problematical.

Certain faunal gradients based on depth, type of bottom, etc., appear irregularly at various places in coastal waters, but the ever present, outstanding gradient is always in connection with salinity and it was not misleading but perfectly correct to point this fact out to paleontologists, who might be interested in former horizons of the shores and shallow seas.

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HESSE, R., C. ALLEE and K. P. SCHMIDT, 1937, Ecological Animal Geography, xiv+597 pp. John Wiley & Sons, Inc., New York.

SINCLAIR, G. W., 1947, Note on "Paleoecological import of salinity." Jour. Paleontology, vol. 21, no. 3, pp. 294–295.

NOTICES

Some 300 supernumerary copies of vol. 1, no. 1, of the CONTRIBUTIONS TO AMERICAN PALEONTOLOGY (1886), containing "Descriptions of New Silurian and Devonian Fossils" by E. O. Ulrich, are available. Copies may be obtained upon request from The Librarian, The American Museum of Natural History, New York 24, N. Y.

The committee on the Illustrated Catalogue of North American Devonian Fossils announce the publication of the first instalment of cards on the corals. This unit (1-E, part a) is devoted to the Auloporidae, and contains 114 cards covering 94 species and nine genera. Final preparation of the unit was done by E. C. Stumm. Copies of this and other units published by the committee may be obtained from the Wagner Free Institute of Science. Philadelphia 21, Pennsylvania.

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Harold R. Wanless, *Symposium on Pennsylvania Problems*

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